The SCIENTIFIC MONTHLY

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Contents

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THE SCIENTIFIC MONTHLY

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TOWARD THE WORLD STATE*

By FREDERICK L. SCHUMAN

WOODROW WILSON PROFESSOR OF GOVERNMENT, WILLIAMS COLLEGE

Arma Virumque. "One peculiarity of this age is the sudden acquisition of much physical knowledge. There is scarcely a department of science or art which is the same, or at all the same, as it was fifty years ago. A new world of inventions . . . has grown up around us which we cannot help seeing; a new world of ideas is in the air and affects us, though we do not see it. . . . If we wanted to describe one of the most marked results—perhaps the most marked result—of late thought, we should say that by it everything is made 'an antiquity.' . . . Man himself to the eye of science has become 'an antiquity.' . . ."

Thus begins a well-known book entitled *Physics and Politics*, written, curiously enough, not in 1945, but in 1869. In its pages the brilliant British essayist, Walter Bagehot, was chiefly concerned with the application to the social studies of the methods of inquiry which had already produced such startling results in the physical and biological sciences. The painstaking decipherment of stars, rocks, elements, and organisms had already begun to reveal the causes and nature of things. Bagehot hoped, with a prescience since fully vindicated, that the decipherment of man himself and all his works, in the manner of an antiquarian studying relics, would resolve the mysteries of the human adventure.

Three-quarters of a century later men have become fearfully aware of a wholly different type of impact of physics upon politics. They are everywhere perceiving, in a mingled mood of frustration and anxious urgency, that science has rendered obsolete many of the familiar habits which men have hitherto followed in the production and distribution of wealth and in the conduct of public affairs. The discovery is not new. William F. Ogburn long ago applied the apt term "cultural lag" to the reluctance of mankind to change social and political stereotypes at a tempo comparable to scientific and technological advance.

Fascism, from whose dominion of nihilism and homicidal mania the United Nations have freed themselves by the narrowest of margins and at a grievous cost, is itself a product of this schism. The new Caesarism flows from man's incapacity to change his institutions in such wise as to use his enormously increased productive resources for wealth and welfare. The idleness of men and machines amid potential plenty breeds

* Reprinted from *The Politics of Atomic Energy*, a pamphlet of the Woodrow Wilson Foundation, 45 East 65th St., New York 21, N. Y., March 1946. To this reprint the author has added a discussion of the Lilienthal-Acheson Report.

bitterness and hatred, driving its victims finally into insane cults of fear and rage and into programs for keeping all machines and men busy preparing destruction and death. It could happen here or in any community where men as producers, consumers, and citizens suffer self-defeat through their own timid conservatism and nostalgia under the pressure of the forces released and the problems posed by the daring radicalism and inventiveness of men as scientists and engineers.

What is new is the realization that the latest triumphs of physics spell either the advent of a Golden Age in which mankind will make all the earth a garden and reach out among the stars —or the immolation of modern civilization in a vast holocaust. The former result requires a revolutionary transformation of almost all the social devices of old, particularly those for ordering (or disordering) the relations among the nation-states. The latter result will eventuate with almost mathematical certainty from efforts to cling to dogmas and practices which are now as irrelevant as the folkways of those who lived in Ninevah and in Ur of the Chaldees.

Awareness of the alternatives breeds not hope but panic, slowly spreading in a tide of fear over the globe. For it is already plain that the minds of men, and especially of politicians, diplomats, and strategists who have vested interests in the *status quo*, stubbornly resist all appeals to revolutionize the world community, even though conservatism now spells the end of all that men hope to conserve. As in all times of troubles, fear moves the majority of the frightened to cling frantically to the fancied safety of the past rather than embark upon the unknown seas of the future. The inescapable fact remains that men have found means of verifying Einstein's hypothesis of 1905: $E = mc^2$—that is, energy, when converted from matter, equals mass multiplied by the square of the speed of light. Four pounds of U–235 or plutonium can heat and light a city by methods which will be perfected within a decade. The same four pounds, by methods already perfected, can destroy a city and convert most of its buildings and citizens into radioactive fumes and ash.

Mars and Pluto. That an atomic war means the end of civilization has already become a truism. "An armament race in atomic weapons, which now seems indicated," writes Chancellor Robert M. Hutchins, of the University of Chicago, in his annual report for 1945, "can lead only to the extermination of mankind; for no one can seriously suppose that the horror of war can prevent war." Some remnants of mankind, to be sure, would survive in areas still habitable and remote from the rubble-strewn wastes of the great metropolitan centers. But "civilization," which is literally the product of city-dwellers and not of countrymen or troglodytes, would scarcely survive the debacle. The mode of life of those still alive may well recall the words of Oswald Spengler:

> Man becomes a plant again, adhering to the soil, dumb and enduring. The timeless village and the "eternal" peasant reappear, begetting children and burying seeds in Mother Earth. . . . In the midst of the land lie the old world-cities, empty receptacles of an extinguished soul, in which a historyless mankind slowly nests itself. Men live from hand to mouth, with petty thrifts and petty fortunes, and endure. Masses are trampled on in the conflicts of the conquerors who contend for the power and the spoil of this world . . . while those in the depths pray, pray with that mighty piety of the Second Religiousness that has overcome all doubts forever. . . . It is a drama noble in its aimlessness, noble and aimless as the course of the stars, the rotation of the earth, and alternance of land and sea, of ice and virgin forest upon its face. We may marvel at it, or we may lament it—but it is there.

It may be taken as a certainty that such a condition of human affairs will

come to prevail in most of the lands of the Northern Hemisphere in the event of an armed conflict of any duration among Great Powers possessing atomic bombs. The war god now wields a weapon containing the flaming fury of the sun and the cosmic power of creation and doom that burns in the farthest stars. By its use, he can swiftly deliver most of the centers of civilization into the hands of the god of death, who is likewise the god of wealth and the deity whose name has been given to the remotest planet and to the new element whereby man may destroy himself.

Only those given to a naive and tragic optimism will suppose that the danger can be averted through treaties among sovereign states outlawing particular weapons or "outlawing war." The former procedure is feckless in the age of total war. The latter is fruitless in any age in any state system composed of separate sovereignties acknowledging no higher power. It was attempted in 1933 by many states in the "Argentine Anti-War Pact." It was attempted in 1928 by all states in the Pact of Paris and in 1919 by most states in the Covenant. It was attempted in 1280 B.C. by Egypt and the Kingdom of the Hittites in the first treaty of which the text remains. The result in every case was the same.

Anarchy and Order. "We are aware," declared President Truman and Prime Ministers Attlee and King in their statement of November 16, "that the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war." The problem of preventing war is not a logical, but purely a psychological, problem. In logic and in all past experience, the problem has invariably and unmistakably pointed toward its own solution. War—i.e., the use of armed violence by organized groups against other groups—is possible only in a community suffering from anarchy. Anarchy is the absence of government. Under anarchy, in Thomas Hobbes' memorable phrase, human life is "solitary, poor, nasty, brutish and short." This is so because all politics under anarchy is "power politics"—i.e., a struggle for control of the means of armed coercion, since all know that violence will be ultimately decisive in determining the distribution of indulgences and deprivations. In a community lacking government the assumption of violence permeates every motive and act of those who are obliged to play politics. And in such a community men bargain over, and fight for, anything which they believe will add to their own fighting capacity and diminish that of rivals and enemies.

The Western State System is obviously such a community. It has always been such a community since the disintegration of the Roman World State and the fading of the medieval ideal of a universal church and a universal empire. To call attention to the obvious would be unnecessary were it not for the prodigious capacity of men to ignore it. International anarchy is not banished by making treaties nor by setting up alliances or leagues resting on the premise of national sovereignty. No community can have government when its separate parts each claim prerogatives admitting of restrictions only on the basis of "international law"—i.e., customs and contracts acceptable to sovereigns and observed only insofar as habit, expediency, good faith, or force may dictate obedience. In extremities all such restraints yield to the imperatives of survival in a brute struggle of each against all.

This fact has long been appreciated by almost all who have given serious thought to the cause and cure of war. The unwillingness of most of modern mankind, even in the atomic age, to acknowledge the fact does not abolish it

nor change the terms of the problem. Unlimited national sovereignty inevitably means international anarchy which inevitably breeds power politics and war. War can be prevented only by abolishing power politics—a consummation wholly beyond realization through moral exhortation or national professions of righteousness. Power politics can be abolished only by replacing anarchy by government in the world community.

The essential attributes of effective government are equally plain and beyond debate. Government has never been achieved, and can never be achieved, through contractual obligation among collective entities, all envisaged as equals and each possessed of paramount power within its frontiers. Neither is government produced by agreements among sovereignties to keep the peace through the collective coercion of peace-breaking sovereignties at the hands of peace-loving sovereignties. This formula of "collective security" was rightly dismissed by Alexander Hamilton as "one of the maddest projects ever devised." Government presupposes an organized authority which is superior, within its defined area of action, to any other authority in the community. It further presupposes that the superior authority will enjoy a decisive preponderance (and, indeed, usually a monopoly) of armed power, and that it will be able to lay down rules of law addressed to, and enforceable upon, individuals rather than upon nations or states. Legislation, administration, and adjudication are prerequisites of all government capable of governing. To talk of government in terms of arrangements falling short of these essentials is to indulge not in an adventure in creative statesmanship but merely in an exercise in humor, hypocrisy, or cynicism.

That global government and unrestrained national sovereignty are mutually exclusive is too obvious to require further proof. Yet demands for the "abolition of sovereignty" are vain since men's minds and hearts are still firmly fixed upon this sacred symbol. What is needed is patient demonstration that in the atomic age all the blessings of sovereignty are mortgaged to the worms through continued anarchy and can only be saved by delegating a limited portion of sovereignty to a supranational authority. In the words of Anthony Eden to Commons (November 22, 1945): "For the life of me I am unable to see any final solution that will make the world safe from atomic power other than that we will abate our present ideas of sovereignty."

Peace By Conquest. One method of abolishing international anarchy is for one sovereignty to subjugate all others. Such was the achievement of ancient Rome in the Mediterranean State System and of the Khans of Tartary throughout most of Eurasia fourteen centuries later. Such, *seriatim*, were the frustrated aspirations of the House of Hapsburg, the France of Bourbons and Bonapartes, the Germany of the Hohenzollerns and Hitler, and the Japan of Hirohito. Thus far, in the Western State System, each aspirant to universal hegemony has ultimately been beaten down by a coalition of all other Powers against it. If past experience is any guide to the future, it can be taken for granted that no single Power will ever be able to establish world government by the sword.

But here, too, the atomic bomb invalidates many past calculations of probability. Had Nazi or Nipponese scientists first perfected the new weapon, it is all but certain that the Fascist coalition would have inflicted a crushing defeat on the United Nations and would have undertaken the establishment of some semblance of global government, based

on slavery and genocide. Speculations as to whether, or how long, such an order might have endured would be futile. The invention of the bomb in America means that the United States has acquired—for a limited period of years, until other Powers begin production—the hypothetical possibility of unifying the world by violence.

The mere mention of the prospect evokes panic among non-Americans and indignation among Americans. Nothing is clearer (to Americans) than the impossibility of the United States attempting to build a *Pax Americana* or an "American Century" by utilizing the bomb to extinguish other sovereignties. Yet other peoples know that democracy is no guarantee against aggression and that in the past the United States has in fact waged campaigns of aggrandizement, behind appropriate façades of morality and self-denial, in Mexico, Cuba, the Philippines, Nicaragua, Panama, and elsewhere, as has Britain in virtually every region of Africa, Asia, and Oceania. With an irresistible weapon temporarily at their sole disposal, Americans might be expected by many abroad to give serious consideration to a program of abolishing all other sovereignties.

That this eventuality is not thus far on the horizon is doubtless due to a combination of rectitude, realism, ineptitude, and indifference. The citizenry of the Republic has displayed commendable capacity to resist temptation. Reflective strategists know that America will be weakened, not strengthened, when atomic weapons are available to other Powers, for America's geographical security against foreign attack will be at end, while America's concentration of industry and population along a narrow corridor between Boston and St. Louis will render it peculiarly vulnerable, albeit less so than Britain. Should a bid for world-wide hegemony fail, its aftermath would be catastrophic. The Government of the United States, furthermore, has no affirmative program in foreign policy which could be implemented by atomic diplomacy and strategy. Its spokesmen have preferred during the months following World War II, as during the years preceding it, to take refuge from the need of having a policy in frequent reiterations of pious platitudes and noble negatives. The legendary "average citizen," moreover, would appear to be too preoccupied with sports, sex, and the quest for private security or riches to have any interest in imposing the American way of life on the rest of the planet through the medium of nuclear fission.

Yet an America reduced to desperation by a new business debacle, followed by prolonged economic stagnation, could conceivably be educated to the advantages of global conquest. But such a disaster, should it occur, might take place at a time when the Soviet Union and other states were already producing atomic bombs in sufficient quantity to retaliate. And a Fascist America, even if "victorious" amid a blasted world, would be as deficient in those qualities of vision, imagination, and moral purpose essential to unify the world by force as were the late Triplice Powers. The effort, even if successful, would engender fierce resentments among millions of its victims. A few score of the vengeful, carrying atomic infernal machines in suitcases, would be able with ease to demolish the major cities of the Republic, assuming that the great metropolises had escaped annihilation in the course of hostilities by virtue of America's temporary monopoly of the bomb. All things considered, the building of a World State by force is no more possible in the atomic age than in the preatomic age. What was once done by the Roman legions and by the invincible cavalry of the Mongols cannot be re-

peated in our time either by the United States or by Britain or by the USSR. This road to world peace through world government is blocked.

Peace By Federalism. The only other available means of achieving a goal which now deserves to be regarded as the *sine qua non* of survival is the application to the world community of those unique principles of governance formulated most impressively by the Founding Fathers of the United States and long since applied in many areas of the British Commonwealth and throughout the USSR. In each case the problem was the same as the world problem of today: how to achieve effective central authority in a society of separate sovereignties without risking the enslavement of the parts by the whole or the enfeeblement of the whole by the parts. The answer is federation.

This prescription for the cure of anarchy is by no means novel, even if its urgency has only now become desperate. Without recalling numerous earlier proposals, it is noteworthy that Theodore Roosevelt urged the need of an "International Police Power" in 1910 and that Hamilton Holt, about the same time, asserted that "the United States must become the model of the United Nations of the World." In 1919 Frederick Jackson Turner warned Woodrow Wilson that any effective international organization must restrict national sovereignty and possess legislative authority. With this proposition the President doubtless agreed in principle, though he saw no way then of obtaining American approval for anything beyond a League—and even in this his optimism proved excessive. More recent pleas for federalism by Clarence K. Streit, Robert Lee Humber, Ely Culbertson, Mortimer Adler, and many others have been followed, since the horror of Hiroshima and Nagasaki, by widespread appeals from physicists, publicists, political scientists, and even a few rare politicians for steps to establish a world federal government as the only visible alternative to mass suicide.

Confusion and befuddlement, both in semantics and in politics, can be minimized by keeping before public attention the precise nature and meaning of federation. Since all Americans, many British subjects, and all Soviet citizens live under federal governments on a national level, it might be supposed that all would possess at least a working familiarity with federal principles. Even casual inquiry, however, reveals that this is far from being the case.

Suffice it to say for present purposes that a federal government is one in which powers of legislation, plus appropriate executive and judicial functions, are divided between central agencies and local units by means of a written constitution which cannot be changed either by the local units or the central organs alone, but only by a process of joint action on the part of both. The central, or "federal," agencies are typically entrusted with limited, specified, or delegated grants of authority, circumscribed by more or less elaborate safeguards against extension or abuse, with all residual powers left to the governments of the local areas or to the people of the union. True federalism likewise involves duel citizenship, since every individual within the jurisdiction and in full possession of civic rights acquires privileges and duties both as a citizen of his local area and of the union as a whole. Federalism also presupposes two realms of law (e.g., State and Federal in the United States, Republican and Union in the USSR), with both bodies of law enforceable on individuals in courts, with all local officials answerable for the observance of federal as well as local law, and with federal treaties, the Union Constitution, and all federal stat-

utes enacted in pursuance thereof given the status of a "supreme law of the land," which all courts are bound to enforce against any conflicting local legislation.

Such arrangements are the antithesis of the traditional concept of "collective security"—i.e., the coercion of sovereign states by other sovereign states or by central agencies set up by them. The judicial application of law to individuals has almost nothing in common with the collective enforcement of treaties on sovereignties, as the framers of the American Constitution clearly recognized. The former process exhibits innumerable instances of its successful use as a means of promoting the rule of law and maintaining order and peace. The latter process, whenever resorted to among "Great Powers," has always led to failure, either through war or through general acquiescence in the violation of obligations. The abandonment of the forcible coercion of states, and the adoption in its place of the restraint of individuals through action by law-enforcement authorities on all levels of government, is the essence of all genuine federalism.

The Art of the Possible. Nothing is simpler for those disposed to accept the argument thus far than to demand a World Federal Government at once, or at least a global Federal Union of Democracies. Such was the procedure of the distinguished participants in the conference at Dublin, N. H., on October 16, 1945. The majority resolved that the UNO should be replaced, either through drastic amendments to the Charter or through a new World Constitutional Convention, by a World Federal Government with a Legislative Assembly, and Executive and a Judiciary. A minority, including Owen J. Roberts and Clarence K. Streit, urged that "simultaneously with efforts to attain a world federal government, the United States should explore the possibilities of forming a nuclear union with nations where individual liberty exists, as a step toward the projected world government."

The proposal of a federation of democracies, while relevant to the exigencies of 1939–40, is not only irrelevant in 1945–46 but deserves to be regarded (were there any possibility of favorable action upon it) as fatal to the larger project. In a world in which the United States and the Soviet Union are the two greatest Powers, and in which any progress toward peace and order requires harmony and unity between them, any project of an Anglo-American Union would be envisaged by all Russians and by many people elsewhere as a maneuver against the USSR. Regardless of the intent of its architects, this would inescapably be its actual role in power politics. This game of the anarchists can obviously not be ended by any federation excluding any of the major Powers. "Union Now With Britain" would thus foster in its most dangerous form a global rivalry which would almost certainly preclude any advance toward a World Union.

Soviet acceptance of Western definitions of liberty, moreover, is not at all a prerequisite of a federation embracing Washington, London, and Moscow. The need of the hour is not a world bill of rights guaranteeing civil liberties, desirable as such an ultimate goal may be, but the delegation of legislative power over atomic energy to a world agency. Ideological and institutional differences are no obstacles to the enterprise if the governments and peoples of all the Super-Powers can be brought to see the shape of the most probable alternative. There can be no future for liberty anywhere if an atomic war comes to pass. Its prevention requires the prevention of war. This task requires redefinitions of liberty everywhere and a world fed-

eration, initially limited in its grant of power to the specific function of making atomic energy the servant and not the destroyer of the race.

On the broader issue, considerations of political psychology and strategy suggest the unwisdom of demands for "scrapping" the UNO, despite its obvious inadequacies. The Philadelphia Convention of 1787, to be sure, displayed sound judgment in abandoning the Articles of Confederation and embarking upon a wholly new departure. In such matters it is often true, as Lloyd George once observed, that "nothing is more dangerous than to try to leap a chasm in two jumps." On the other hand, no world constitutional convention is politically conceivable until after the UNO has been established and subjected to several years of trial. The amending process in the Charter (cf. Art. 109) offers the possibility of early action. Prevailing attitudes render the implementation and progressive reform of the UNO in the direction of federalism a far more feasible undertaking than the abrupt repudiation of what has already been done and the creation *de novo* of an alternative scheme.

In neither course can there be full assurance of safety nor even of progress toward the goal. Men are easily victimized by blind fears and fatuous hopes amid the atomic world revolution of our time. But the very magnitude of their anxiety and the diversity of their confused quests for salvation would seem to dictate a pattern of action which will minimize the alarms bred by proposals for revolutionary change and maximize the reassurances which go with stability, continuity, and orderly reform.

How to Begin. In all human journeys, as Alice was once sagely informed by the Cheshire Cat, the wayfarers are likely to approach their destination only when they know where they wish to get to, where they are, and where they have come from. Progress in the present enterprise will be proportionate to the knowledge of the travelers not only of the principles of federalism but of the nature and purport of the UNO.

The new organization is clearly not a government but a league of sovereignties. It differs from the Geneva League, however, in one vital respect. The framers of the Charter abandoned the unworkable device of keeping the peace through the assumption of duties by all sovereigns to apply collective coercion against any sovereign that might break the peace. In its place was put the principle of the unity of the Great Powers. America, Britain, and Russia (the Super-Powers), along with France and China (the pseudo-Powers), are pledged not to attempt coercion of one another and to apply collective coercion against others only when they are of one mind among themselves and also have the approval of two of the six nonpermanent members of the Security Council.

The meaning of the "veto" in the Yalta formula and in Article 27 of the Charter is that collective measures of enforcement for keeping the peace shall be applied only on the basis of unanimity among those sovereignties which alone are possessed of decisive power. None of these can be coerced by any or all of the others without a major war. None of these can coerce outside sovereignties against the will of any or all the others without promoting the rivalries among the powerful which lead to war. The objective is peace. Hence the wisdom of necessity of unanimity among the permanent members of the Security Council, which can be effective only insofar as it functions as an executive committee of united Great Powers.

If these considerations, already signed and sealed in the Charter, are taken as a point of departure for next steps, then it is evident that what is needed

and what is possible for the transitional period immediately ahead is a redefinition of the authority of the Security Council, without (at this stage) any change in its composition or voting procedure. The Council is charged by Article 24 with "primary responsibility for the maintenance of international peace and security." This responsibility plainly cannot be discharged without authority over the use of atomic energy on a world scale. To transfer such authority elsewhere would reduce the Council to a shadow. To envisage such authority in terms of advice to governments to conclude treaties "outlawing" war or prohibiting atomic bombs would be to misconstrue entirely the nature of the problem and the experience of the past. What is called for—if the current issue is to be met adequately and if the ultimate goal is to be served effectively—is the grant to the Security Council of legislative power in the field of atomic energy.

Such a departure from precedent presupposes an initial agreement among the Super-Powers, followed by a global accord acceptable to France, China, and the other United Nations. Specific, limited but adequate power to enact statutes regarding atomic energy can readily be conferred upon the Security Council through the device of a general treaty. Such statutes must become part of the supreme law of the land in all member states, enforceable on individuals through national and local courts, with the International Court of Justice having ultimate appellate jurisdiction. Global atomic legislation cannot as yet be enacted by majority vote. The Council as constituted under the Charter could best enact its statutes by the procedure already provided in Article 27—i.e., unanimity among the permanent members, plus assent by any two of the other six.

Nothing more than this is needed to begin the building of a federated world. Nothing less than this will suffice to cope with the problem of the atomic bomb. However inadequate such a procedure may appear to those concerned with democratic values and majority rule, it would seem to represent the only acceptable procedure for the immediate future. Given this, reforms and advances will enter into the realm of the politically possible. Without this, all the days ahead may be wasted in wrangling and vain illusions while an atomic arms race gains headway and drives the nations along the road to death.

How Not to Begin. The decisions and indecisions in high places during the half-year following the vaporization of Hiroshima and Nagasaki present the general appearance of a perfect formula for frustration and ultimate tragedy. The physicists, to be sure, have displayed a large measure of vision, maturity, and responsible statesmanship. Almost with one voice they have insisted that there is no "secret," that no defense against the bomb is possible, and that no control can be effective save through a world authority. In a statement of November 16, the Federation of Atomic Scientists realistically urged an Anglo-American-Soviet conference to propose measures of international control for submission to the other United Nations. The majority of politicians, on the other hand, have displayed a consistent preference for daydreams, nightmares, and nonsense.

Aside from various fatuous proposals already noted, all schemes to vest control of atomic energy in the General Assembly of the UNO fall into this category. The contention that such a procedure would be "democratic" is wholly without merit. Democracy assumes the equality of people. The rule of the equality of sovereign states is the negation of democracy by any definition. An Assembly of

sovereign equals would be one in which Albania, Yemen, Luxembourg, and Guatemala had the same voice and vote as China, Russia, America, and Britain. Such a body, moreover, can never be anything more than an irresponsible congeries of the impotent, certain to reenact the evasions and failures of Geneva. To divorce responsibility from power is to insure disaster.

The Truman-King-Attlee declaration of November 16, 1945, is scarcely more encouraging. Its framers rightly concede in their preamble that "no adequate military defense" against the bomb is possible; that "no single nation can in fact have a monopoly" of its use; and that "no system of safeguards that can be devised will of itself provide an effective guarantee against production of atomic weapons by a nation bent on aggression." But the leaders of Atlantica then seek to distinguish between the use of atomic energy for military purposes and its use for peaceful, industrial purposes. The distinction has no present or immediately prospective reality since the only practicable use of atomic power thus far is for war. Sovereign states, moreover, are inexorably driven to use all resources and techniques for military purposes when confronted by total war. Despite their recognition that "the military exploitation of atomic energy depends, in large part, upon the same methods and processes as would be required for industrial uses," the framers of the declaration base the balance of their statement upon a fictitious dichotomy, offering to exchange scientific information "for peaceful ends with any nation that will fully reciprocate"; declaring (inconsistently) that "scientific information essential to the development of atomic energy for peaceful purposes has already been made available to the world"; and finally proposing (with even greater inconsistency) to "share, on a reciprocal basis with others of the United Nations, detailed information concerning the practical industrial application of atomic energy just as soon as effective and enforceable safeguards against its use for destructive purposes can be devised."

In this jumble of false premises and contradictions, nothing is clear save the decision of the authors to share something which is nonexistent in return for something they acknowledge to be unattainable. The *quid* is information on the "peaceful" or "industrial" use of atomic power which, as of 1945–46, is many years off. The *quo* is a system of "effective, reciprocal, and enforceable safeguards acceptable to all nations" and already conceded in the statement itself to be beyond achievement.

The cream of the jest is to be found in the tasks assigned, *seriatim*, to the proposed UNO commission—i.e., to make recommendations and proposals:

(*a*) For extending between all nations the exchange of basic scientific information for peaceful ends.

(*b*) For control of atomic energy to the extent necessary to ensure its use only for peaceful purposes.

(*c*) For the elimination from national armaments of atomic weapons and all other major weapons adaptable to mass destruction.

(*d*) For effective safeguards by way of inspection and other means to protect complying States against the hazards of violations and evasions.

The first assignment is pointless, since there is as yet no "basic scientific information" relative to atomic energy "for peaceful purposes," and if there were the only obstacle to its world-wide dissemination would lie in the present policies of the American, Canadian, and British Governments. The remaining charges to the Commission can only be regarded as ludicrous or meretricious. There is no way in a world of fully sovereign states of insuring the use of atomic power "only for peaceful purposes," nor of eliminating weapons of mass destruction from national arma-

ments, nor of establishing effective safeguards against the use of such weapons. If the members of the Commission are alert and honest, they will report that the duties assigned them are impossible within the frames of reference of existing scientific knowledge and the reign of unrestricted sovereignty among the nations. If they are dishonest or naive, they will indulge in further circumlocutions. The task of mastering the bomb cannot be begun until those in high places abandon old sterectypes and new fantasies and face stubborn facts.

The Dawn of a Hope. The Moscow Conference of December 16–26, 1945, opens new prospects for progress. The false choice of "keeping the secret" or "giving the bomb to Russia" was ignored by Byrnes and Bevin, who sagely devoted their efforts to restoring the crumbling foundations of Anglo-American-Soviet collaboration. Upon this base must rest all hope for the UNO today and for world government tomorrow. The new compromises dispose, at least partially and temporarily, of the twin bogies of Soviet "isolationism" and of Anglo-American "atomic diplomacy" against the USSR. The Moscow formula on atomic energy saves all faces and removes many obstacles in the way of further advance. The Kremlin associates itself with the proposals already made by Washington, Ottawa, and London. The UNO Commission will be sponsored by the Big Three, plus France, China, and Canada. It will be established by the General Assembly but will consist of states represented on the Security Council (plus Canada) and will act under the direction of, and report to, the Security Council.

The Commission, to be sure, is charged anew, by the resolution voted by the Assembly in January, with the same four tasks which remain, as before, impossible of accomplishment in an ungoverned and ungovernable world of sovereign equals. But it is further asked to "inquire into all phases of the problem and make such recommendations from time to time with respect to them as it finds possible." The immediate future depends upon the disposition of the Commission to avail itself of its opportunities under this enlarged grant of advisory authority. If it limits itself to conventional platitudes and traditional devices, thousands will cheer—but millions will suffer eventual disenchantment and all-but-certain tragedy. If it boldly proposes the provisional vesting of legislative power over atomic energy in the Security Council, many will denounce its suggestions in 1946, but all will bless its work in the years and decades which lie ahead—assuming that the UNO makes such proposals the guideposts of the new age.

Upon the willingness of the world community to take this decisive step depend man's hope and man's fate. The primary obligation is more than ever that of the United States. America's duty is likely to be creatively fulfilled only if Americans perceive and insist upon the need for global legislation, and only if they abandon their fictitious monopoly of "secrets" and their actual monopoly of stockpiles of atomic explosives (still being manufactured by the turn of the year at the rate of 6.6 lbs. per day) without waiting for the final devising of some perfect system of "effective safeguards." American trust in the UNO is the precondition of making the UNO trustworthy. In the wise words of Mr. Attlee to Commons last November: "Where there is no mutual confidence, no system will be effective."

Despite the long delay in constituting and convening the UN Commission, a vastly helpful blueprint is provided by the *Report on the International Control of Atomic Energy*, prepared by Chester I. Barnard, J. R. Oppenheimer, Charles

A. Thomas, Harry A. Winne, and David E. Lilienthal (Chairman) as consultants to the Secretary of State's Committee on Atomic Energy, consisting of Dean Acheson, Vannevar Bush, James B. Conant, Leslie R. Groves, and John T. McCloy. This report, released March 16, 1946, is a masterpiece of unanswerable logic which should be read and pondered by all citizens of the United States and of the United Nations. It distinguishes not between "peaceful" and "military" uses of atomic power but between "safe" and "dangerous" operations. The latter are defined as:

> Prospecting, mining and refining of uranium and, to a lesser extent, thorium; the enrichment of the isotope 235 by any methods now known to us; the operation of the various types of reactors for making plutonium, and of separation plants for extracting the plutonium; research and development in atomic explosives.

Such activities, as differentiated from medical use of radioactive tracers and the production of power and neutron sources from denatured U–235 and plutonium, are "dangerous" under any imaginable circumstances when left to national exploitation. The report therefore suggests the creation of a UN Atomic Development Authority which, under the direction of the Security Council, would own and operate throughout the world all uranium mines and all laboratories and manufacturing plants using fissionable materials in their dangerous form. It would also assume control of research and of all inspecting, licensing, and leasing functions designed to make impossible the manufacture of atomic bombs and to make available atomic power and its by-products for the good of all mankind.

No summary can do justice to these proposals, of which Professor I. I. Rabi rightly says in his preface that they have "no equal unless we go back to the annals which describe the origins of the basic law of this land." Suffice it to say that the program here offered is modeled on the Tennessee Valley Authority in the sense that it contemplates the establishment of a public corporation (in this case global rather than national) to own and operate all atomic energy plants and all sources of raw materials and to make "safe" products available for medical and industrial uses through lease or sale. TVA represents the most hopeful synthesis yet achieved between public economic planning and free business enterprise in a context which preserves the virtues of both and the vices of neither. A world ADA offers promise of effectively "outlawing" the bomb, of reconciling "national sovereignty" and "world government," and of bringing into being in functional terms the nucleus of a World State, limited at the outset to the most important single field of human endeavor in the atomic age. Such an agency would also promote a workable world-wide synthesis between "collectivism" and "individualism," thereby helping in the long perspective of coming years to bridge the chasm between the Soviet Union and the Atlantic democracies.

It is devoutly to be hoped that this plan will be made the official policy of the United States and the basis of the work of the UN Commission. The plan is adequate because it postulates that national governments will accept the superior authority of a world agency in this field and because it implies that the rules regulating the agency, as well as those issued by it, will in fact be a supreme law locally enforceable on individuals throughout the world.

E Pluribus Unum. If the cheerful assumptions may be made that Anglo-American-Soviet concord can somehow be restored and that global legislative authority over atomic energy can somehow be vested provisionally in the Security Council, then it becomes germane to

inquire as to what steps beyond this are needed to achieve the Parliament of Man and the Federation of the World. All reasonable citizens will agree with Secretary Byrnes (Charleston, November 16, 1945) that "we must not imagine wishfully that overnight there can arise fullgrown a world government wise and strong enough to protect all of us and tolerant and democratic enough to command our willing loyalty." What is called for is not a demand for Utopia nor yet a dismissal of all proposals for change as "Utopian," but immediate, constructive steps toward transforming the UNO into a workable federation. Ernest Bevin and Anthony Eden have expressed willingness to consider proposals in this direction. Official Washington, still in the grip of pride and prejudice, and official Moscow, still haunted by suspicion and fear, are both silent as these words are written.

If the creation of a world legislative authority in the limited but crucial field of atomic energy be regarded as the initial step toward replacing treaties by statutes in a gradually widening area of planetary policy-making, then attention must be given to devising a world legislature more adequate for its purposes, more democratic in its selection, and more federal in its structure than the Security Council can ever be. Ingenious proposals for complex schemes of representation are likely to prove acceptable and practicable in inverse ratio to their ingenuity and complexity. The long record of successful federal governments provides a formula of extreme simplicity.

With no important exceptions, all federations have reconciled the limited (but still real) sovereign equality of states with the efficacy of central agencies by the device of a bicameral legislature, in one chamber of which States (or Republics, Provinces, Cantons, etc.) have been represented in proportion to population and in the other chamber of which they have been represented as equals. Since federal legislation ordinarily requires a majority vote in each house, local rights, central authority, majority rule, and the sovereign equality of states are all effectively synthesized. In the community of nations an elective General Assembly, composed (purely by way of illustration) of one deputy for every 5,000,000 inhabitants or fraction thereof, would be a body in which America, Britain, the Soviet Union, France, and China would have, respectively, 28, 10, 38, 8, and 75 representatives for their metropolitan territories, with such states as Brazil, Mexico, Canada, Turkey, and Poland having from 3 to 9 delegates each. States the size of Australia, South Africa, Colombia, Greece, and Hungary would have 2 apiece, and all less populous states one each. To represent all states equally in an upper chamber or Security Council would create a body at once too cumbersome for its special functions and probably unacceptable to the Great Powers whose actual responsibility for the common defense and the general welfare is heaviest. It would therefore appear wise, at least provisionally, to retain the existing structure of the Council, with its five permanent seats and its six nonpermanent seats rotated among lesser states through election by the Assembly.

Irrational fears and hoary inhibitions would doubtless preclude any immediate general acceptance of the view that all legislation, within the carefully prescribed limits of the Federal Charter, should be enacted by a simple majority vote of both chambers. Some form of unanimity among the Great Powers and various safeguards for the lesser states would be needed to secure approval of the new dispensation. Ultimately, however, the familiar principle of majority rule (within a context of specified powers, constitutional prohibitions, division of powers, separation of powers, and

other "checks and balances") would commend itself to the good sense of mankind if it appeared that the provisional arrangements were working satisfactorily. Beyond this, the Security Council might well be extended into a more plausible facsimile of a democratic legislative chamber. A World Cabinet, responsible to one or the other or both chambers, might eventually come into being to perfect the structure.

Yet all such mechanical details would be incidental in a world which had once grasped and applied the precepts of federalism to its common problems. The great revolution, inaugurating a new era in world politics commensurate with the new problems of the atomic epoch, would find its central meaning elsewhere: first, in the enactment of world law not through contracts among diplomats representing sovereigns but through statutes passed by legislators representing the peoples and governments of the nations; and, secondly, in the enforcement of law not through promises and threats among sovereigns but through the adjudication of the rights and duties of individual plaintiffs and defendants in local, national, and international courts.

Large scale lawbreaking, requiring military action for its suppression, might still occur, regardless of whether the Union permitted or forbade secession. The members of the Union would be obliged, for their own safety, to require even a seceding state (assuming such a right were granted) to obey the law regarding atomic power, since any failure to do so, in the name of "nonintervention" and "respect for sovereign rights," would be potentially disastrous to all. Yet all necessary coercion would be directed not against states in their corporate capacity, but against groups of lawless and rebellious individuals who, in most imaginable instances, would be opposed by many of their own fellow-citizens as well as by the moral and physical power of the World Union. Even should insurrection assume widespread and persistent form, it would still lack the legal and psychological attributes of war, since the issue would lie not between states and states but between organized mankind and a group of outlaws. Atomic bombs would obviously never be used in such conflicts so long as the Union had a monopoly of their control, for the purpose of insuring obedience to law would be defeated by any weapon which indiscriminately annihilated the law-abiding along with the lawbreakers.

Once accepted, the federal principle, would, in Anthony Eden's phrase, "take the sting out of nationalism." All would be citizens of the World Republic as well as of their nation-states. None could plausibly practice the preachment of "My country, right or wrong!" Beyond this great divide, a broad vista of liberty under law would open out for all mankind, with innumerable possibilities of new political and social adventures in human betterment successively presenting themselves through the years to come. To speculate now upon these opportunities, however, would be a work of supererogation.

The Shadow of a Doubt. Only those with an indomitable faith in a beneficent providence or in man's rationality and capacity for self-fulfillment will be disposed to assume in the troubled dawn of 1946 that any such vision as has here been projected is likely of realization. Narrow is the road and strait is the gate into the promised land. *Homo sapiens* is a bewildered, fear-stricken, devil-ridden, and hate-filled caricature of a god and a beast. As Norman Cousins puts it, modern man is "obsolete"—or at least unable to live much longer in the company of his most cherished convictions and passionate prejudices. It may be, as H. G. Wells has argued, that the

species has already demonstrated its unfitness for survival. Those addicted to this entirely reasonable belief will dismiss all hopes as vain and all dreams as dust, certain to be lost in the endless darkness which will fall upon the world before another generation has reached middle age.

If universal fear becomes man's fate, as city after city leaps skyward in pillars of cloud by day and pillars of fire by night, some among the straggling survivors will no doubt remember in vain lament the words of Isaiah:

> The earth is defiled under the inhabitants thereof; because they have transgressed the laws, changed the ordinance, broken the everlasting covenant. Therefore hath the curse devoured the earth, and they that dwell therein are desolate; therefore the inhabitants of the earth are burned and few men left. . . . Fear, and the pit, and the snare, are upon thee, O inhabitant of the earth. . . . The earth shall reel to and fro like a drunkard, and shall be removed like a cottage; and the transgression thereof shall be heavy upon it; and it shall fall and not rise again. . . . Then the moon shall be confounded, and the sun ashamed. . . .

Without global government there will be no escape from annihilation. Before there can be global government, the UNO must be transformed into something adequate to the needs of the time. Before this transformation can proceed, a new harmony and a common resolve to serve shared purposes must be reaffirmed and translated into action by the leaders and the peoples of America, the British Commonwealth, and the Soviet Union. Toward this end there is little that Moscow can do save to practice forbearance, patience, and restraint. Its rulers know that any specific program they may urge will be met by many in the West with suspicion or contempt. Those who have unleashed the whirlwind have the duty of proposing the means of turning it to the ends of life rather than to the service of death. Responsibility lies with Britain and the United States.

Woodrow Wilson and Franklin D. Roosevelt, David Lloyd George and Winston Churchill, loom through the fog of days gone by as beacons of hope and courage in the annals of Anglo-American statesmanship. But there is little in the balance of the record to suggest that the rulers and voters of the Atlantic democracies possess in peacetime the qualities demanded by the imperatives of tomorrow: insight, foresight, imagination, and persistence in doing what is necessary rather than what is expedient.

The judgment of Dr. Herbert V. Evatt, Australian Foreign Minister, speaking in New York on November 27, 1945, may prove to be correct:

> It should be clearly understood that such a proposal (as world government) is quite impossible of acceptance. The plain fact is that the nations and peoples of the world are not yet prepared to surrender the rights of self-government in order to be governed by a central executive and a central legislature in which most of them would have a tiny and very insignificant representation.

In a time of testing, men may indeed turn back to the past while those upon whom the future depends may continue to fumble and fail. If not, a requiem must sound for the age-old ways which have always spelled chaos and now spell doom. If so, the bell will toll for all the achievements and aspirations of the great society which Western mankind has built through the centuries. In either case, the words of the ancient wise men, asked by their king for an aphorism appropriate to all possible occasions, will still hold true: "These things, too, will pass away."

THE LOST CAUSE

By Clarence R. Wylie, Jr.

Steadfast, my flesh, we dare not now grow soft;
We are too old to know a second spring,
And still in heart too young to bid farewell
To the bare mountains, and the woods, and streams
Where first we proved our manhood. Other lads
Can share these yet a while, for soon enough
Comes the dark day when sharing will be done
And what was wholly ours will pass to them.
To work, my flesh, the game is lost to us
But pleasant still to play.

We are the sturdy and strong of limb,
We are the brave and gay,
Breathless we stand at the golden bend
Where the bright years curve away.

No one believes us now, but we were strong
Beyond belief in those wild, wondrous days.
No challenge passed unheeded, and we proved
All things were possible by doing all.
Men tried to match us, and to each we gave
Choice of the game, and then in friendly bouts
Out-jumped, out-swam, out-fought the best of them.
And when in solitary paths we roved
Through our beloved wilderness, we found
In all our wanderings no crag too steep
To be our vantage point above the world,
Nor pack so heavy but we'd shoulder it alone
And take the portage at a trot.

Lean on the wind and embrace the storm,
Sail where the sea is white,
Shout out the cry of exultant youth
Through the clamor of the fight.

All now are dead who might remember us,
Dead in this life by wine, or wealth, or work
Unmixed with play, or just for want of faith.
Only as we remember does the past survive.
Oh, flesh, we dare not now grow soft,
We must not kill the brave, proud boy we were.

THE NATURAL HISTORY OF THE MUD SNAKE

By GEORGE P. MEADE
COLONIAL SUGARS COMPANY, GRAMERCY, LOUISIANA

THE mud snake *Farancia* is a large, brilliantly colored reptile (Fig. 1) with a sharp spine, or "horn," on the end of the tail, which is the basis of snake myths, superstitions, and unwarranted fears. The tail spine is not unique, however, as it is also present in some other snakes.

My own interest in the mud snake stems from a back-yard reptile collection in which *Farancia* has been the subject of special attention during the past 15 years. The mud snake is quite common in the region of Gramercy and about 150 specimens have been in my possession, all caught within a radius of 10 miles. A wire mesh cage with soft earth bottom partly covered with grass or leaves and properly shaded from the midday sun affords surroundings in which the snakes live and breed under conditions as nearly natural as is practicable in captivity. A large, shallow, galvanized iron pan provides sufficient water for their needs.

Besides the term mud snake, which is descriptive of the habits but not of the appearance, many fanciful names have been applied such as "stinging" snake, "horn" snake, and "red-bellied" snake. In this section of Louisiana the species is invariably referred to as the "stingaree," although this is the accepted common name of a fish, the sting ray. Among the French-speaking population the mud snake is *piquant queue*. The generic name *Farancia* is a coined word without significance. The genus has only one species *abacura*, and this name is from the Greek *abac* (checkered) and

Photo by D. Dwight Davis

FIG. 1. THE MUD SNAKE, *FARANCIA ABACURA* SHOWING ITS CONFORMATION AND TAIL SPINE. (FROM SCHMIDT AND DAVIS, *Field Book of Snakes*).

FIG. 2. TWO SNAKE CHARMERS
LARGE MUD SNAKES ARE DOCILE AND USUALLY DO NOT RESENT HANDLING.

ura (tail), from the under-pattern of the tail.

The range of *Farancia* is roughly bounded by a line from Virginia through Missouri and thence to eastern Texas, although the distribution is not uniform throughout this area. Specimens have been taken in southern Indiana. The preferred habitat is swamps, muddy regions, ditch bottoms, or the shallow water at the edges of lakes. The climate and topography of southern Louisiana are ideal for this reptile.

Two subspecies, *Farancia abacura abacura* and *F. a. reinwardtii*, called the Eastern and Western mud snake, respectively, have recently been distinguished, but the two varieties are so nearly alike in gross characteristics that individuals can best be identified on the basis of the locality in which they are found. *F. a. abacura* occurs in the Atlante Coast states and Florida; *reinwardtii* in Alabama, Louisiana, Texas, and the Mississippi Valley. All descriptions and observations given here apply to the Western subspecies *reinwardtii*.

The mud snake is the largest of the harmless species in southeastern Louisiana. The record specimen for my collection was 73 inches long with a diameter of nearly $2\frac{1}{2}$ inches, and many examples over 66 inches long have been kept in captivity for extended periods. Large, well-fed captives are generally docile (Fig. 2), although the smaller ones frequently show evidence of nervousness by probing with the tail spine, by rapid convulsive jerking of head, or by hiding the head in a tight ball of

coils. Attempts to bite have never been seen or reported.

The coloration and pattern are extremely showy; the back shiny black from snout to tail tip with more than 50 brilliant red markings extending about halfway up the sides. The belly is of the same brilliant red with the black markings on the side extending into it to give a red-and-black checkered, or tessellated, effect which extends to the tail tip. Adding still further to the bright coloring are the yellow lip plates and chin scales, spotted with black, the yellow changing to orange as it shades into the red of the underbody. For a week or two before shedding the color is a light, translucent blue-gray, giving a ghostly appearance, and the snake is hardly recognizable as the same reptile by the layman. The effect is as if the snake had been dipped in a lead-colored lacquer, obscuring, but not entirely covering, the pattern beneath (Fig. 3).

The body of *Farancia* is cylindrical, the neck only slightly constricted, with the head flattened and tapering. The tongue is quite small, and the eyes are small, flat, and inconspicuous, indicative of the burrowing habits. Females are generally large and heavy-bodied, whereas the males are usually shorter and slenderer, with relatively longer tails than the females.

Until about 12 years ago little was known regarding the food of the mud snake. References in the literature mentioned frogs, mud eels, and salamanders as the probable food, and Ditmars reported feeding a few captive specimens on tadpoles; but keepers of zoos and private collectors reported to me that they had no success whatever in feeding this large and handsome reptile and most of them did not care to accept donations because of the certainty of starvation.

In April 1933 while on a collecting trip near Gramercy with a young friend, I saw a large mud snake swallowing one of the long eel-like amphibians *Amphiuma means tridactylum*, which are extremely common in this area. This amphibian has four vestigial feet and is known locally as the "lamp eel" and by the Negroes as "lamp-eater." Two specimens of *Farancia* were already in my collection, and when one of these "eels" was placed in a shallow pan of water and a 57-inch mud snake introduced with it, the mystery of the feeding habits was solved. The normally quiet, sluggish snake attacked with a speed and viciousness that were astonishing, and the struggle which followed was so violent that the two antagonists were thrown out of the water onto the ground.

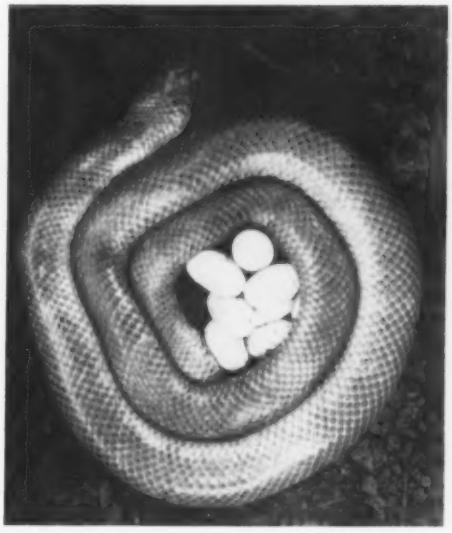


FIG. 3. A MOTHER SNAKE
PREPARING TO MOLT ONE MONTH AFTER LAYING.

This spectacular contest between the brilliantly colored snake and the gray, slimy amphibian has been repeated hundreds of times in my backyard (Fig. 4), and visitors are amazed at the extreme vigor of the snake's attack, which is in such sharp contrast to its seemingly docile and torpid nature. Noise or the presence of an excited audience, handling during feeding, or other disturbances do not distract the mud snake. No special feeding conditions are necessary, although shallow water or moist

ground has been found preferable as the slimy mud eel dries quickly in the absence of moisture and becomes sticky and hard to engulf. Among the many scores of these snakes that have been in my collection no specimen has persistently refused to feed during the summer months except, of course, during the premoulting period. On several occasions, large examples brought in from collection trips have fed immediately on being dumped out of the bag, and one 5-footer that had been tied securely with wire and carried in from the swamps on the end of a pole, seized a proffered amphibian promptly on release. Nevertheless, after a feeding great care must be exercised in handling the snake or it may disgorge either immediately or, worse yet, two or three days later when the food has been partly digested. *Farancia*, unlike most snakes, has to fight its prey, and veterans of many such feedings carry scars where their victims have bitten fiercely into the hide.

In order that they may breathe while swallowing large prey, many species of snakes are able to extend the windpipe beyond the front edge of the lower jaw, and this adaptation is particularly essential to *Farancia* because of the size and nature of the food. This protruding glottis, about the size and appearance of a piece of macaroni, may be seen in Figure 4 at the middle of the snake's under jaw. It is withdrawn and protruded as the snake needs air.

COMPLETE records of the breeding habits of snakes are comparatively rare since

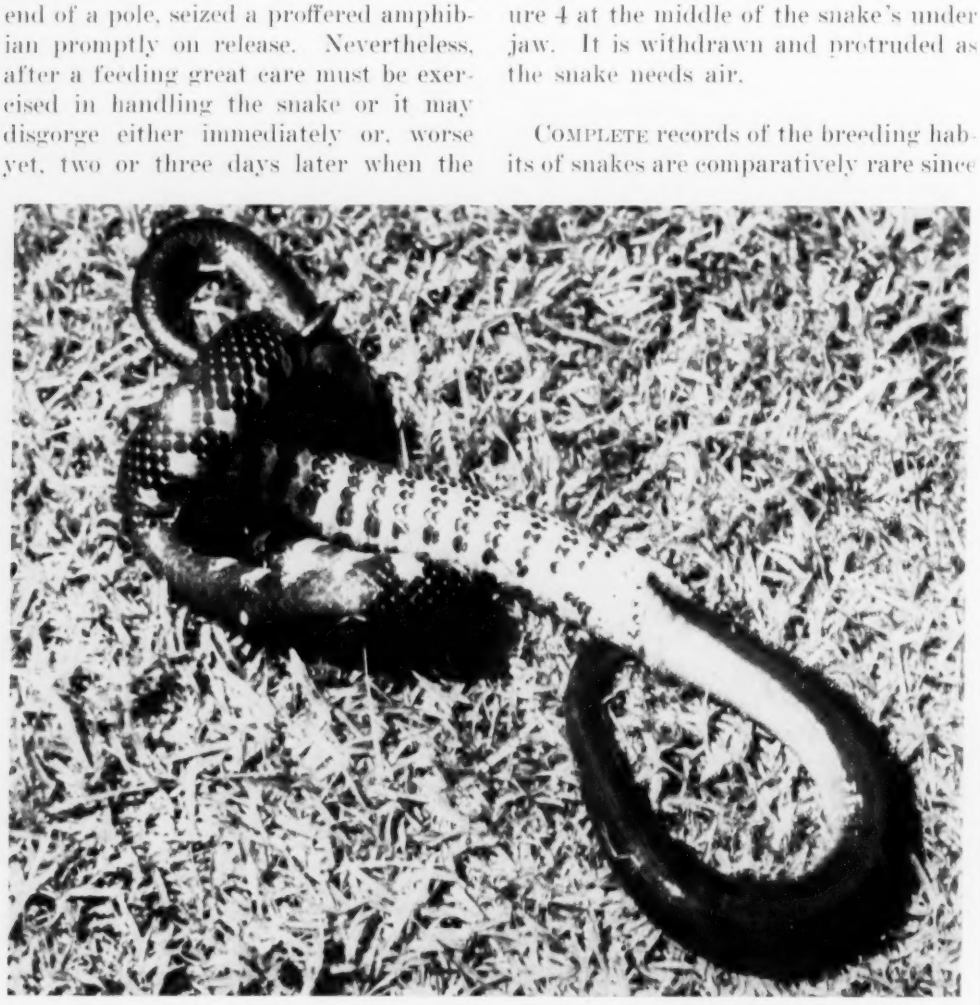


FIG. 4. *FARANCIA* FEEDING ON *AMPHIUMA*
THE GLOTTIS OF THE SNAKE MAY BE SEEN PROTRUDING AT THE CENTER OF THE LOWER JAW.

breeding in captivity is not usual and observation of such activities in the wild state is obviously difficult. The first recorded case of the breeding habits of *Farancia* was that of a 67-inch female in my collection that had been in captivity more than a year and a recently caught male, only 42 inches long and weighing 1 lb. 10 ozs., less than one-third the weight of the female. The mating took place on July 11, 1936, and 28 eggs were laid on September 5, just 8 weeks later. They were cream-white, smooth, nonadherent to one another, and quite regular in size and shape, varying in the shorter diameter from 21 to 24 mm. and in the longer from 42 to 48 mm. As in all snake eggs, the shells were tough, flexible, and leathery. As will be seen in Figure 5, the snake attempted to keep the eggs within the coils of her body.

These eggs were incubated in bagasse, the residue from the grinding of sugar cane, that had been dried and sterilized for sale as litter for small chickens. The material, which is absorbent and clean, was kept moist by sprinkling it every few days. (It has since been found that snake eggs are much more readily incubated in a tightly closed glass jar, with a moist cloth on the bottom on which the eggs are placed, permitting observation throughout the incubation period.) Snake eggs "grow" during incubation by absorbing moisture, and after 7 weeks, these were almost the size of small chicken eggs. Nineteen of the eggs hatched on October 30 and 31, 8 weeks after laying and 16 weeks from the mating date.

The young were quite slender and smaller than had been expected, averaging about 8 inches in length. In conformation and pattern they were strikingly similar to the parents, black above, checkered black and red below, with the tail tip equipped with a needle-sharp spine. The yellow color of the chin and lip plates, which was pronounced in the male parent, was entirely absent. The brood were lively and active, burrowing briskly into the moist bagasse in which they were hatched. They never attempted to strike or bite but when handled would first show the bright pattern under the tail and then stab ineffectively with the diminutive spine. During the first week they went through the characteristic color changes of mature specimens before molting, and on the seventh day they all shed their skins.

Seven other clutches of eggs that have been recorded in Gramercy had from 15 to 30 eggs per clutch, and all were laid a month to 6 weeks earlier than the lot described above. The earliest laying date was July 14, the latest August 13. Hatching of these various sets of eggs occurred between September 15 and October 4, the period of incubation varying from 7 to 9 weeks. From these data it would appear that in this region *Farancia* generally lays from 20 to 30 eggs in late July or early August and that hatching occurs late in September or early in October.

Conclusive evidence is accumulating that the mud snake takes care of her eggs, although many books and treatises erroneously state that no maternal care is shown by any snake except the python. The photograph (Fig. 5) of the egg laying described above shows the position of the mother after the deposition of the last egg. It seemed evident that an attempt was being made by the snake to keep the eggs within the coils of her body, but whether this was for the purpose of incubating them or merely to hold them in a close group could not be determined. The eggs were removed from the mother immediately and incubated artificially, with the results previously described.

The first direct evidence of maternal care was observed in the summer of 1939. On August 10 a 52-inch female was found in one corner of the cage, coiled around 18 eggs somewhat more closely than in the previously observed instance.

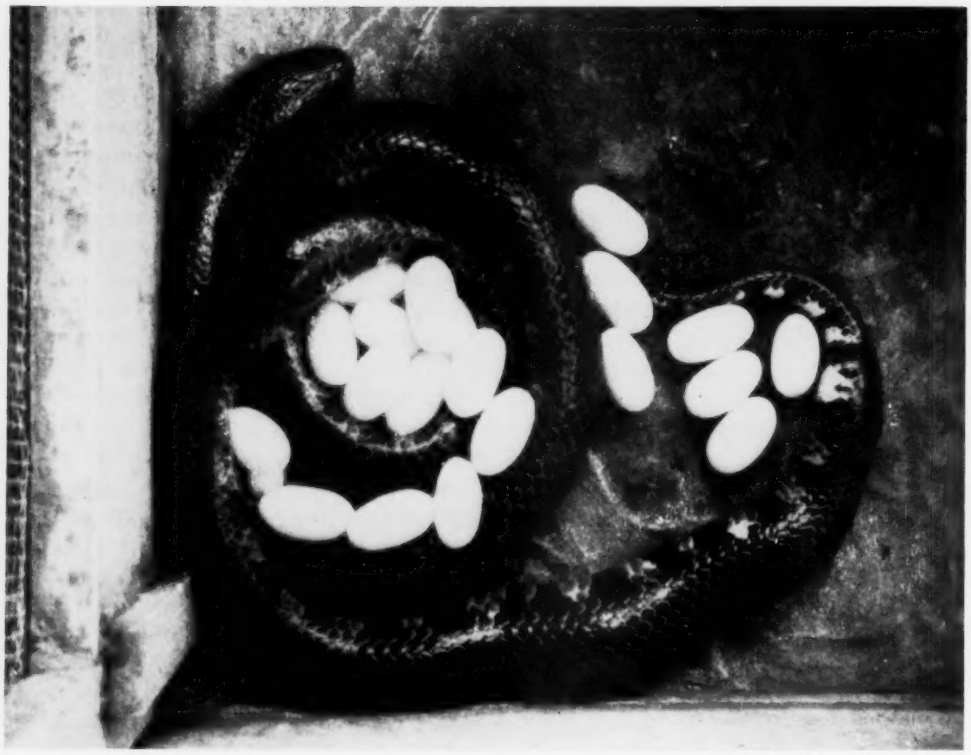


Photo by Henry G. Gerstner

FIG. 5. *FARANCIA* JUST AFTER LAYING

All other snakes were removed, and the mother and eggs were protected from the sun and rain by inverting over them a large, shallow, galvanized iron pan with the edge raised to permit exit and entrance. During the first 6 days the snake changed her position slightly, pulling the clutch more closely together and covering the outer eggs more fully with the coils of her body.

On the sixth morning the snake was found at the opposite end of the cage, and the egg group was somewhat scattered. It was feared that the maternal interest in the eggs was at an end, so half of the clutch was removed and incubated artificially. The other 9 eggs were left on the floor of the cage and the pan inverted over them as before. When the mother was found tightly coiled about the eggs on the following morning there was little doubt of her intent.

During the next 6 weeks the mother left the eggs twice to shed her skin, 4 times to defecate, and was removed from the cage 4 times to feed on *Amphiuma*. It is significant that the shedding and defecation were done at the far end of the cage from the eggs, since cast skins attract ants almost immediately in this climate and the excreta is voluminous following heavy feedings. During the incubating period the snake did not resent handling, offered no objection to being removed from the eggs, and did not appear nervous or disturbed. She did not seem anxious to return to the eggs when away from them but later would be found coiled closely around them in the manner shown in Figure 3.

The 9 eggs artificially incubated all hatched on September 28, 7 weeks after laying. The next day a torrential rain flooded the cage where the mother snake was tending the rest of the clutch, so the

eggs were removed and placed in an incubating jar where they hatched the following week. The young were similar to those of the first brood.

As a coincidence, while the above study was in progress a letter from Philip D. Evans, of Kansas City, reported that a farmer in Dinkler County, Mo., claimed to have killed a large "stinging snake" under a board near a drainage ditch, and that the snake was coiled around a clutch of about 15 eggs. Evans secured some of these eggs and these hatched about 2 weeks later, which "would suggest that this species in some cases does remain with the eggs." Another instance was observed by Goldstein in Florida in which a 6-foot specimen of *F. a. abacura* was found on August 21 coiled in a hole in the side of a mound. Embedded in the walls of this excavation in 3 successive rows or layers were 40 eggs, with the inner eggs partly protruding from the sides of the wall. From examinations of various eggs that were opened, Goldstein concluded: ". . . that the female had stayed with them for some time." He found a *Farancia* cast skin nearby, "probably from our female specimen."

More striking evidence of maternal care was observed in the summer of 1944. A 5-foot specimen of *reinwardtii* laid 22 eggs on July 14 in the same open cage and remained coiled about them. The procedure of covering snake and eggs with a moist cotton sugar sack and then with the inverted galvanized pan was followed. The next day when the pan was lifted for observation the eggs were completely covered by the cloth, with the snake coiled on top of its outside edges. The effect was that of a cloth hat with the eggs under the crown and the snake resting on the brim. The shaping of the cloth and consequent covering of the eggs could not have been achieved more accurately by hand. As before, the snake was removed 3 times to feed on *Amphiuma*, and molting and defecation were effected as far from the eggs as the cage would permit. Each time the snake would return, generally during the night, to coil about the cloth-covered eggs. On August 18 the cage was flooded with rain and the eggs dispersed. The snake appeared to lose all interest in them, so they were removed and placed in a jar for artificial incubation; two hatched on September 20.

A noteworthy point is that, so long as the mother snake remained coiled about the eggs, there was no evidence of attack by mildew, ants, or maggots, yet eggs artificially incubated here must be carefully protected from these three destructive agencies. Whether or not the presence of the mother has some protective value is a matter for conjecture.

THE spine on the end of the tail is a hard, hornlike terminal scale that has been the subject of much comment and speculation, both scientific and otherwise. Among laymen, it is thought to be poisonous, and the ignorant are positive that it is a deadly "stinger" capable of killing not only human beings and animals but also trees. Lumbermen and trappers working in the nearby swamps have been found to be much more afraid of the sting than of the bite of a rattlesnake or cottonmouth. A common belief, expressed in some early descriptions of the species, is that the spine is retractible and can be "darted in and out."

Various suggestions have been made in the scientific literature as to the function of the tail spine, but none of these has been the result of extended observation. The commonest idea is that of protection, because many specimens when picked up or restrained prod the hand with the tail, in rare cases to the extent of drawing blood. Even hatchlings, as previously pointed out, stab with their diminutive tails. Another suggested use is that the tail spine serves to hold the slimy prey during feeding, but in the several hundred feedings that I have

witnessed no such use has ever been observed. One authority states that "it probably functions during burrowing," and others have suggested that the sharp tail is driven into the ground when the snake is struggling with *Amphiuma* or dragging the amphibian out of a hole; but again no such action has ever been noted either in my captive specimens or in snakes in the wild state.

The bluntness of the spine in mature examples is evident. Curious observers are disappointed to find the famous "horn," or "sting," of a large mud snake no sharper than a blunt pencil point, although that of smaller specimens is generally sharp. This difference seems to have some significance, as it has been repeatedly observed that the younger or smaller specimens use the sharp spine as a goad when the amphibian prey bites and holds onto the snake. Under these circumstances, particularly when seized near the head, the snake stabs the victim so sharply with the spine as to cause it to release its hold. Blood is frequently drawn, and long deep scratches are inflicted on the soft body of the amphibian. Large *Farancia* have sufficient bodily strength to break the hold without the use of the spine. It is of interest that this species has exceptionally strong jaws, far stronger than those of most snakes.

The story of the snake that takes its tail in its mouth and rolls like a hoop is persistent. Most authorities say that this myth is commonly identified with the mud snake and indicate that the possession of the tail spine is in some way related to the hoop story. Ditmars suggests that a possible explanation is the "habit of *Farancia* of occasionally lying in a loose coil . . . almost forming a circle" and having the appearance of "a discarded bicycle tire." A much more definite basis for the hoop-snake myth may be seen while *Farancia* feeds on *Amphiuma*. The larger snakes, especially, have a habit of rotating on their longitudinal axis when they are in a position to start engulfing the prey; that is, when the jaws have grasped either the head or tail of the victim. This rotation is frequently so rapid as to suggest that snake and victim are driven by a pulley, and the brilliant pattern of the snake is blurred by the motion. In the course of this peculiar axial rotary maneuver, the struggling pair have been seen to form almost a complete circle, and the rotation then carries them along the ground still in the circle or hoop and still revolving about the curved axis of the snake. Colored moving pictures of this phenomenon invariably bring forth the comment, "There's the hoop snake."

The picture of the first feeding ever observed (Fig. 6) shows this hooplike position of the pair. In this instance, the amphibian is being swallowed tail first, so that its mouth might easily have grasped the tail of its captor. If this had occurred (I have never seen it happen) and the axial rotary motion had proceeded, the illusion of a revolving hoop would have been even more vivid. Whether this complete circle has ever been observed or not, there seems little doubt that the rapidly rotating near-circle must have been seen many times during feedings in the wild state, affording ample basis for the hoop-snake story in the southern lowlands.

One of the few reported studies of hibernation of snakes was made at Gramercy on a 65-inch *Farancia*, that weighed 3 lbs. 11 ozs. on October 24, 1934. On November 4 it was placed on a layer of mud at the bottom of a packing box sunk in a hole near a small pond, the bottom of the box being at the water level and the top covered with wire mesh. The snake did not appear until mid-February, remaining above ground for several hours. Its weight on March 6 was found to be 3 lbs. 10 ozs., only 1 ounce less than the weight over 4 months before. On successive appearances *Amphiuma* was refused in spite of the long fast,

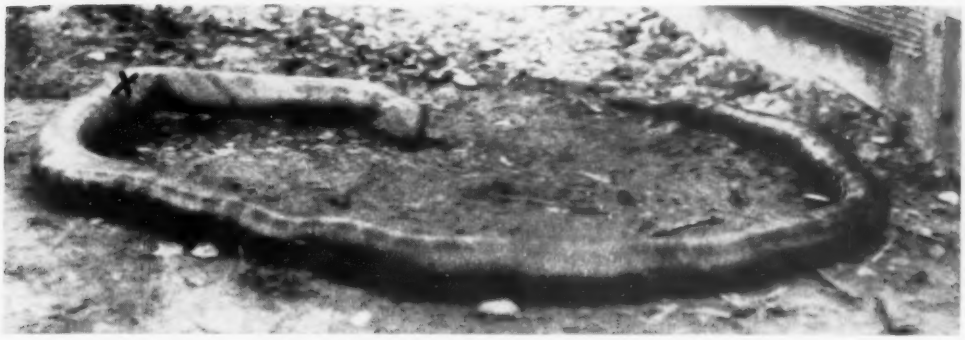


FIG. 6. A HOOP SNAKE?

Farancia TAKES A HOOPLIKE POSITION WHILE ENGULFING *Amphiuma*. X MARKS SNAKE'S HEAD.

but on March 26, nearly half a year from the last feeding, the snake was finally removed from the box, and a small amphibian was taken. The snake appeared to be in excellent condition, no more sluggish than usual, and tongue motions were frequent.

Experience has since shown that hibernation in captivity requires no such elaborate preparations. A few bushels of dead leaves or grass placed in the outdoor cages and loosely covered with tar paper afford the shelter desired by nearly all the species in my collection.

The twin plagues of the snake collector, mouth-rot and mites, have never appeared in my specimens of *Farancia*. Two conditions that have been fairly frequent are white water blisters on the skin and some sort of white growth (fungus?) that affects the eyes. The water blisters seem to be caused by excessive moisture because they disappear after shedding if the snake is removed to a dry cage before the trouble has become too prevalent. A few blisters have been cured by washing with a mild antiseptic, but if the blisters are very extensive the snake is released.

The eye condition first appears as a whitening of one or both eyes and may possibly be started by failure of the eye plates to shed. The eye becomes distended until it is the size of a pea, completely opaque, and seemingly ready to burst. No treatment here has been successful, although Karl Kauffeld, of the Staten Island Zoo, reported some success with dilute potassium permanganate.

Very little has been learned of the rate of growth of mud snakes either in captivity or in the wild state, though this would certainly be an interesting study if regular food supply could be assured. The feeding habits of freshly hatched specimens have never been demonstrated. Goldstein reported that earthworms were taken, but none of the hatchlings at Gramercy ever showed any interest in such food. They probably eat hatchling *Amphiumae*, which are extremely plentiful here in early spring. One zoo keeper reported that small *Farancia* fed readily on strips of flesh cut from a large *Amphiuma*, but no young have been at hand since this information was received.

Another unsolved problem is whether maternal care of eggs in the wild state is the rule. The observations of Goldstein and Evans and the less reliable reports from local lumbermen, together with the evidence of care in captivity, are convincing but not absolutely conclusive. If these reported cases are not isolated instances the question remains, Why does the mud snake brood or incubate the eggs when other snakes of similar habitat find this unnecessary? Richmond reports no indication of such care in the rainbow snake *Abastor*, which resembles *Farancia* in many habits and characteristics.

COLOR PHOTOMICROGRAPHY

By J. V. BUTTERFIELD
SCIENTIFIC BUREAU, BAUSCH AND LOMB OPTICAL COMPANY

SUCCESSFUL photomicrographs are assured only when the principles of good microscopy and critical illumination are adhered to. Owing to the characteristics of present materials for black-and-white photography, errors in adjustment of the optical system, character of the light source, and variation in exposure may never be revealed in the finished print. The color films, on the other hand, do not possess the latitude of the black-and-white negative materials. This means that careful adjustment of the optical system and correct exposure are essential. In addition, the color films pose a further problem in the matter of the quality of light to which they are exposed.

Without proper concern for the requirements of the color film and reasonable familiarity with the principles of illumination for the microscope, attempts to produce photomicrographs in color are certain to be disappointing.

The Camera. In general, the requirements for a camera in color photomicrography are not different from those for work in black and white. Probably the most nearly universal type of camera consists of a light-tight, adjustable bellows, capable of being extended at least 10 inches, with interchangeable focusing screen and negative holder at the back and a means for making a light-tight coupling between the front board and the microscope eyepiece tube.

Owing to the higher cost of color films in professional sizes and the popularity of the 35 mm. roll film for record purposes, the photomicrographic camera can be simply one of the small cameras designed to handle this type of film.

It is not advisable to project the image from the microscope eyepiece directly to the film with a projection distance less than 10 inches, especially with objectives of short focal length. Therefore, in the event it is desired to use a miniature camera directly over the eyepiece of the microscope, the regular camera lens should be left in place and focused for infinity. The microscope should be focused to project a real image of the specimen at a considerable distance (several feet) from the eyepiece, and the camera then carefully positioned over the microscope eyepiece without changing the focus of the microscope.

The Microscope. The microscope stand should be a good professional model, preferably fitted with a corrected substage condenser. For the best results with color, especially at the higher magnifications, the apochromatic or fluorite (semi-apochromatic) objectives are desirable. The compensating type of eyepiece should be used with these objectives. Achromatic objectives and the Huygenian eyepieces are satisfactory at lower powers and in some cases may prove adequate in medium and high-power ranges.

A substage iris diaphragm is an important adjunct if properly used, for by its means it is possible to exercise an appreciable control over contrast and depth of focus.

While referring to the substage equipment of the microscope, it might be mentioned that a device employed by the earlier microscopists, but apparently little used today, can be an aid to color photomicrography; that is, the use of a microscope objective as a substage condenser. The present substage condensers have been designed to work with the full range of microscope objectives used on a

particular stand, especially the corrected forms which are made divisible so that separate elements are suitable for certain objectives. Since the focal lengths are long with respect to their numerical aperture, the condensers do not carry the high degree of correction incorporated in the objective. At the lower powers where the working distance of an objective is sufficient to work through the specimen slide, excellent results are obtained by using an achromatic objective as the substage condenser. Most research-type microscopes are supplied with an adapter for using an objective in the substage. The numerical aperture and focal length of the objective in the substage should be at least very nearly that of the objective above the specimen slide. The difficulty with this arrangement, of course, arises with the higher power objectives because the working distance becomes so short that specimens must be mounted between cover glasses rather than on the conventional specimen slide.

The Light Source. For critical microscopy and photomicrography it is desirable that the light source be homogeneous and of concentrated form. The effectual source in most systems of critical illumination is approximately 3 mm. in diameter. Appropriate lamps affording a source of this size are the 6-volt, 18-ampere ribbon filament lamps and the carbon arc lamp using electrodes 5 to 8 mm. in diameter. In the majority of incandescent tungsten lamps with clear envelopes and coiled filaments, the filament arrangement does not provide the homogeneity desirable for microscope illumination. Although lamps of this type and the inside-frosted lamps with rather large envelopes are not directly applicable as sources, on occasion it may be desirable to use one of these types. The method of applying them will be described later.

The complete illuminating unit should consist of a housing for the lamp and a condensing lens of the correct focal length to form an image of the light source about 30 mm. across its smallest dimension at a distance of 10 to 20 inches. It is desirable that the condenser consist of an arrangement of spherical lenses or an aspheric lens to provide a degree of correction for spherical aberration. Typical illuminating units suitable for color work are the Bausch & Lomb Research Microscope Lamp incorporating the ribbon filament or the illuminating units as supplied with the Bausch & Lomb Photomicrographie Apparatus.

An iris diaphragm directly in front of the lamp condenser is a distinct advantage, though not essential. Besides aiding in the alignment of the system, it provides a definite control for the size of the illuminated field.

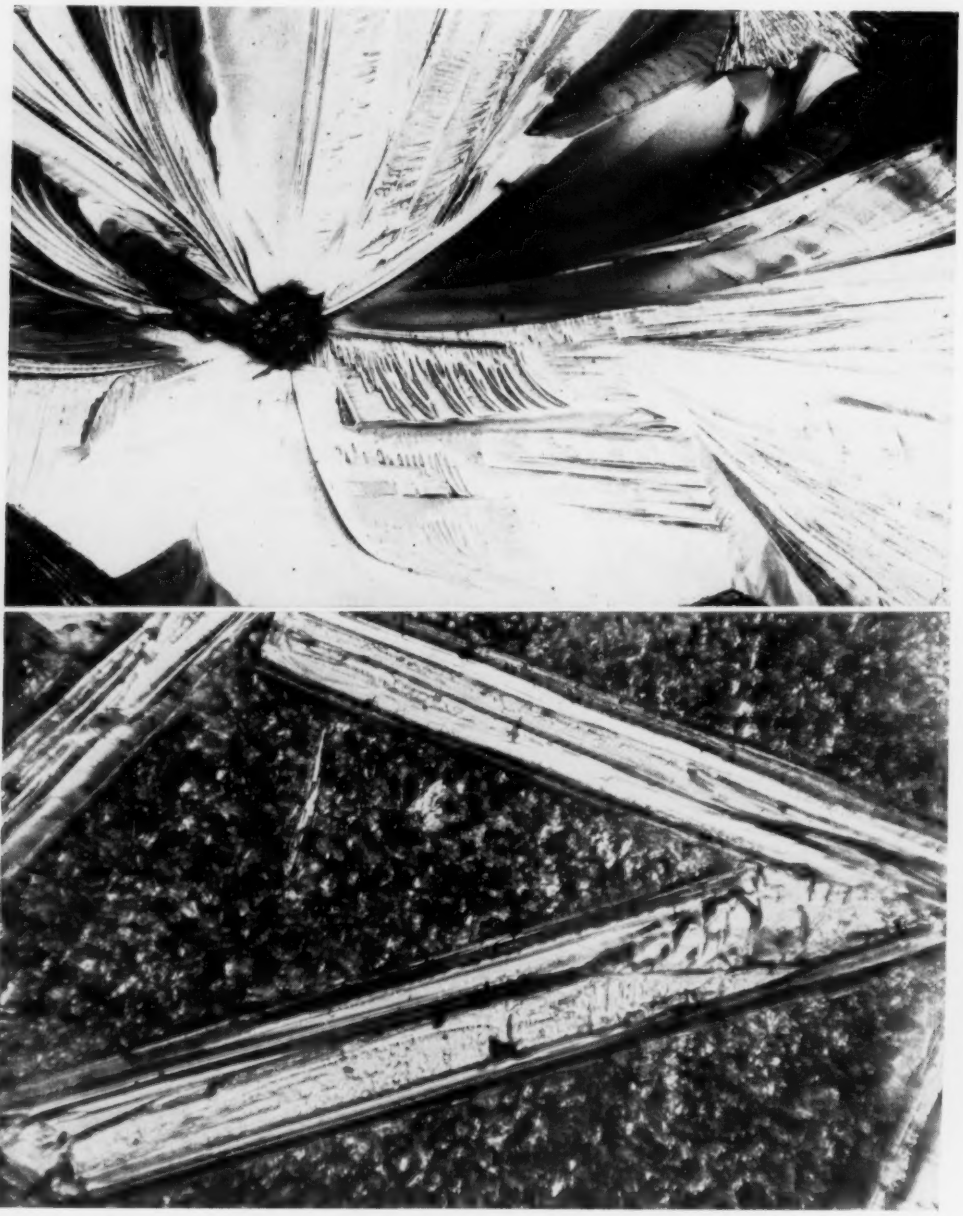
Light sources having a discontinuous spectrum, such as gaseous discharge tubes, or a combination of line spectrum and continuous spectrum (as is the case with the mercury-tungsten arc lamp) are not suitable for color work.

Color Films and Their Relation to the Light Source. Two types of film are available in both Kodachrome and Anseo Color. That for use in light of daylight quality is adjusted to a color temperature in the range of 5,400° to 6,000° K. The films for use with artificial light sources are adjusted to particular incandescent tungsten lamps designed to provide a definite color temperature at particular operating voltages. For obvious reasons, the tungsten type films are most generally used in photomicrography.

Kodachrome, Type B, is adjusted to a color temperature of 3,200° K. to match the color temperature of a series of 3,200° K. lamps manufactured by the General Electric Company. The popular 35 mm., Type A, roll film, however, is adjusted to a color temperature of 3,450° K., matching the color temperature of the familiar

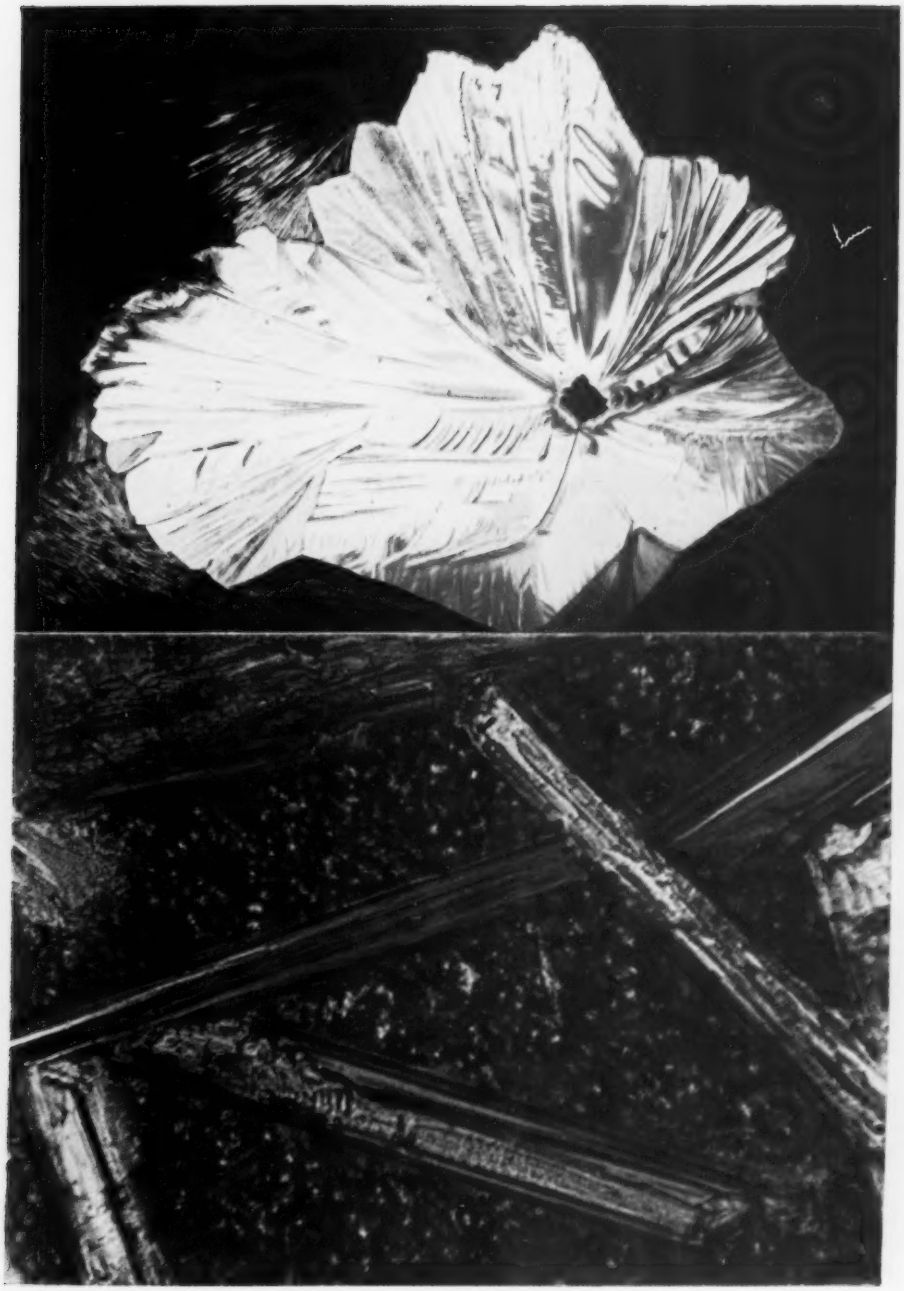
TARTARIC ACID CRYSTALS

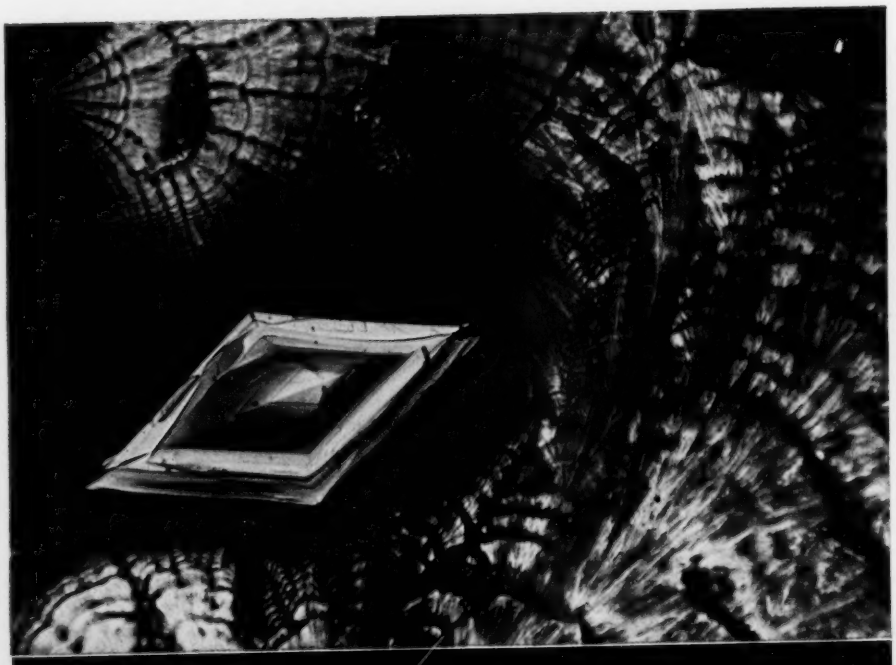
OBTAINED BY ACCELERATED EVAPORATION OF A CONCENTRATED SOLUTION IN THE PRESENCE OF GELATINE. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 10 ×; OBJECTIVE, 32 MM. MICRO TESSAR F: 4.5; EXPOSURE, 1 SEC.; FILM, ANSCO COLOR, TUNGSTEN TYPE, SHEET. COLOR PLATES FROM THE BAUSCH AND LOMB OPTICAL CO.

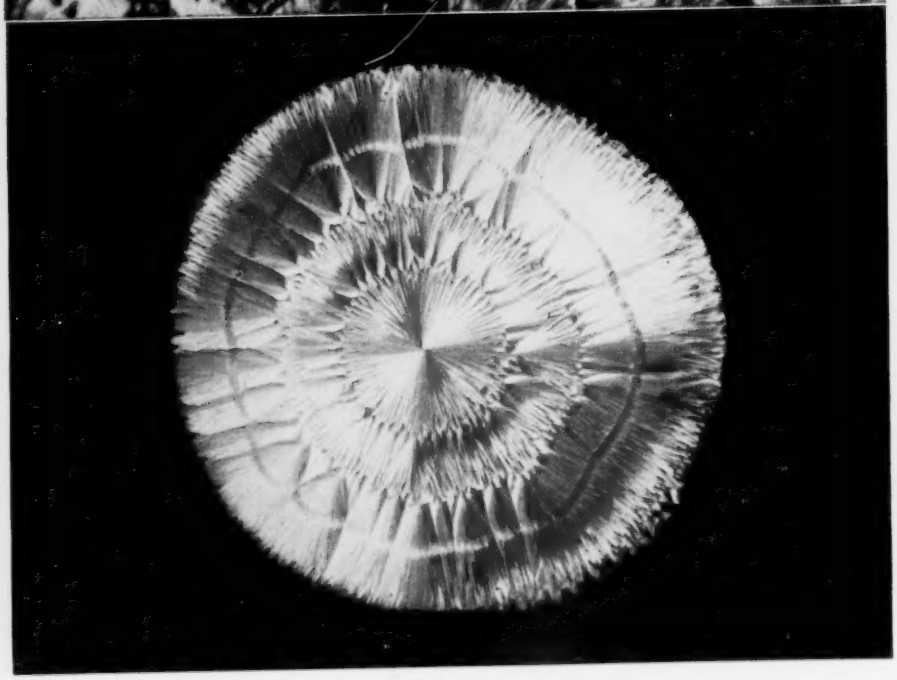


AMMONIUM SULPHATE CRYSTALS

OBTAINED BY RETARDED EVAPORATION OF A CONCENTRATED SOLUTION AT ROOM TEMPERATURE. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 75 ×; OBJECTIVE, 22.7 MM. 0.17 N.A. ACHROMATIC; EYEPIECE, 5 × HYPERPLANE; EXPOSURE, 2 SEC.; FILM, ANSCO COLOR, TUNGSTEN TYPE, SHEET. COURTESY B. & L. OPTICAL CO.

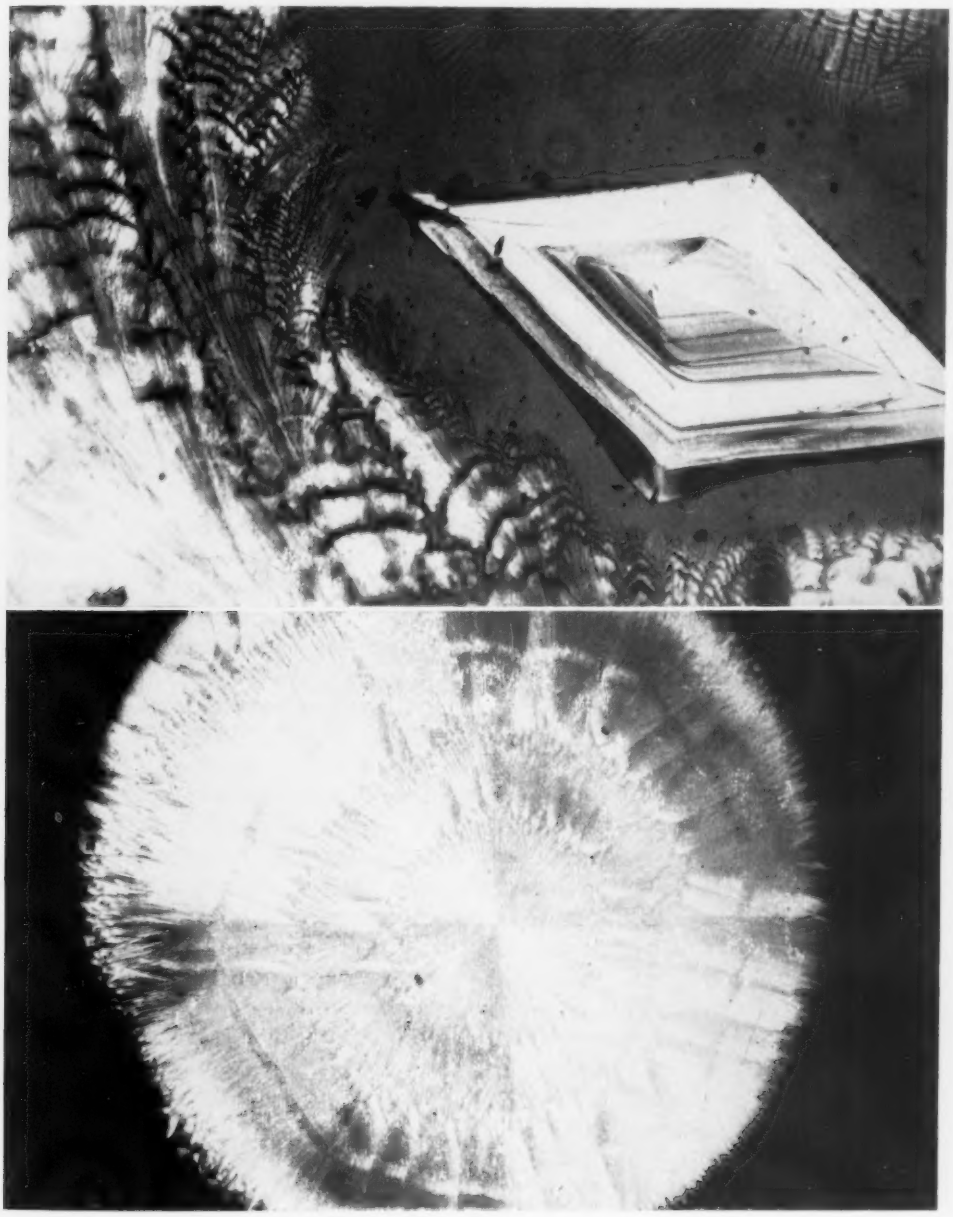






ASPARAGINE CRYSTALS

OBTAINED BY RETARDED EVAPORATION OF A CONCENTRATED SOLUTION. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 80 ×; OBJECTIVE, 22.7 MM. 0.17 N.A. ACHROMATIC; EYEPIECE, 5 × HYPERPLANE; EXPOSURE, 2 SEC.; FILM, ANSCO COLOR, TUNGSTEN TYPE, SHEET. COLOR PLATES SUPPLIED BY THE BAUSCH AND LOMB OPTICAL COMPANY.



SALICINE CRYSTALS

OBTAINED BY RETARDED EVAPORATION OF A CONCENTRATED SOLUTION AT ROOM TEMPERATURE. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 30 ×; OBJECTIVE, 22.7 MM. 0.17 N.A. ACHROMATIC; EYEPIECE, 5 × HYPERPLANE; EXPOSURE, 1 SEC.; FILM, KODACHROME, TYPE B. COLOR PLATES FROM THE BAUSCH AND LOMB OPTICAL CO.

photoflood lamps. In the case of Anseo Color Film, both the professional film and the roll films are adjusted to 3,200° K. The choice of the size of film to be used will be influenced by the type and quantity of work to be done, the form of camera employed, and perhaps by the light source at hand.

Although the carbon arc lamps designed for use in photomicrography and the 6-volt, 18-ampere ribbon filament lamps are excellent light sources with respect to source size, their color temperatures do not coincide with the color temperature requirements of the color films. It is necessary, therefore, to alter the quality of the light from these sources.

The matter of adjusting the color temperature of the carbon arc lamp is complicated somewhat by the presence of excessive ultraviolet in its spectrum. To adjust the color temperature of the arc it is necessary first to introduce a filter to remove the excessive ultraviolet. Since the color temperature of the arc is somewhat above the 3,200° or 3,450° K. rating for the tungsten type films, it is then necessary to introduce filters to reduce the effective color temperature of the visual light transmitted by the U.V. filter. The U.V. filter can be made up in liquid form and placed in the water cell normally used for heat absorbing purposes, so that the solution performs the two functions at once.

The 6-volt, 18-ampere ribbon filament lamp operates at a color temperature in the range of 2,800° to 3,000° K. With a ribbon filament lamp operating at normal voltage, a Wratten 78 C filter placed in front of the lamp condenser will in many cases provide an effective color temperature sufficiently near 3,200° K. to give very satisfactory results with Type B Kodachrome or Tungsten Type Anseo Color Film.

To determine the effective color temperature with a sufficient degree of accuracy, a device such as the color temperature meter made by the Eastman Kodak Company and described by Lowry and Weaver[1] should be employed. With such a device it is possible to operate the lamp at a reduced voltage and select a suitable filter to provide the required color temperature. Matching of sources and film is discussed by Loveland.[2, 3]

When using photoflood lamps as a light source with type A Kodachrome, the need for photometric filters is eliminated. To use one of these lamps and to obtain the effect of a small source, the procedure is as follows:

A sheet of ground glass is mounted in front of the lamp to afford adequate diffusion. A light shield is then prepared by punching a hole 3 to 5 mm. in diameter in a piece of sheet metal. The shield is mounted in front of the ground glass, and the condenser lens mounted in front of the aperture in the shield. The light shield should be placed very close to the ground glass. A housing should be placed around the lamp; however, it must be constructed so as to permit adequate ventilation for the lamp. The condenser lens should have a focal length on the order of 30 to 60 mm. for convenience and should have a relative aperture of about f: 1.0. The illuminating unit should be capable of projecting an image of the small aperture about 30 mm. in diameter at a distance of 12 inches or more from the condenser lens.

Alignment of the Optical System. In order to produce satisfactory photomicrographs in either black and white or color it is essential that the optical system be properly aligned and that the requirements for critical illumination in the microscope be met.

In practice, the Köhler form of critical illumination is generally used. In this system the condenser lens of the illuminant is focused to project an image of the light source into the opening of the substage condenser lens. The distance from the illuminant to the microscope substage must be great enough so that the projected image of the source will

completely fill the maximum opening of the substage condenser. The substage condenser in turn is then focused by means of its rack-and-pinion adjustment to form an image of the lamp condenser directly on the specimen.[4, 5, 6] During this adjustment the iris diaphragm of the substage condenser should be fully open. The plane side of the mirror should be used to reflect the light beam into the substage condenser if the microscope is in the vertical position.

With the proper substage condenser in the microscope the image of the lamp condenser formed on the specimen plane should be large enough to fill the field included by a given eyepiece and objective combination.

The camera should be so supported that it centers over the microscope eyepiece and so that the plane of the film or focusing screen is perpendicular to the axis of the microscope. If a lens is incorporated in the camera, the lens should be located close to the microscope eyepiece. The narrowest point in the light beam emerging from the eyepiece (the Ramsden disc) should be located at the plane of the iris diaphragm of the camera lens if possible.

Color Compensation. Because of the somewhat complicated optical system involved in the photomicrographic system incorporating a microscope, the light reaching the color film in some cases may not be of the identical quality as that leaving the illuminating unit, even though color temperature adjustments have been made at the source. The color imbalance may be caused by selective absorption of certain colors by the optics in the system. A filtering action may also occur in the specimen-mounting medium. Lack of chromatic correction in the substage condenser in the microscope or incorrect focusing of this element may also introduce false color. This color effect may not become troublesome except at the higher powers, and even then it may not be considered sufficiently serious to warrant corrective measures. The condition will vary from one setup to another, and no one system can be employed to remedy all cases. Deficiencies in the light reaching the color film can be corrected, if desired, by introducing special color filter solutions prepared by Eastman Kodak Company.[2, 3]

At the lower powers, up to 100 X or so, and when photographing specimens such as those illustrated here, it is doubtful if such color compensation is actually necessary. No color compensation was found necessary when the originals of the accompanying illustrations were made.

Exposure. Methods have been described whereby photoelectric exposure meters or visual photometers are used to determine the correct exposure time for the color films.[7, 8] Such devices, if carefully used, are convenient and will give accurate determinations, provided the quality of light and illumination conditions in general have been correctly adjusted for the particular color film. In the event some form of photometer cannot be used, the correct exposure time can be determined photographically by first making trial exposures on black-and-white materials and then calculating the exposure time for the color film from the known speeds of the two materials.

Theoretically, the black-and-white material used for making such exposure tests should be of the reversal type.[7] However, in determining the exposure for the originals of the accompanying illustrations, ordinary negative materials were employed. The illustrations presented here were selected from a series of color photomicrographs including stained sections as well as chemical crystals in polarized light. Type B Kodachrome and the professional Anseo Color Sheet films were both used in making the complete series. Lacking other means of exposure determination, it was decided to try the exposure test

method with black-and-white negative material, choosing the exposure giving a good range of tone when the negative was developed in a normal manner.

The negative material used for making the exposure tests included both Eastman Panatomic X and Defender Fine Grain Panchromatic Films. The Wratten X–1 filter was placed in the illuminating beam when the trial exposures were made. The negatives were processed in Kodak formula DK–60-A developer for 4 minutes at 20° C. Previous to exposing each color film an exposure test strip was made on the negative material. From this test strip the exposure judged to be correct was chosen. A full-size negative including a large portion of the specimen was then exposed and developed to provide a better over-all judgment of the exposure. The ratio of the recommended Weston speed numbers for the negative and color material was then applied to determine the exposure for the color film. At the outset 3 color films were exposed per specimen, using the estimated time and exposures 25 to 50 percent shorter and longer. The color films were returned to the manufacturer for processing.

The finished transparencies were compared with the original specimen projected onto the camera ground glass when possible to do so. It was found that the exposures determined by the method described produced satisfactory results, and the practice of including the longer and shorter exposures was discontinued with subsequent films.

It should not be concluded that this method of exposure determination is presented as an approved and certain procedure. As indicated earlier, the method is contrary to theory. However, the results obtained were entirely satisfactory and the method apparently is applicable in the event approved methods[7] cannot be employed.

The photomicrographs presented here were taken on the large Bausch & Lomb Photomicrographic Equipment. The originals were made on 5 × 7 film. No color compensation was employed. A 78 C filter was used to correct the color temperature of the light source to 3,200° K.

Polaroid discs were used as the polarizing elements. One at the illuminator, directly in front of the Wratten 78 C filter, acted as the polarizer, and the other above the eyepiece (immediately behind the Micro Tessar in the case of the Tartaric Acid illustration), as the analyzer. A first order red retardation plate was held between the analyzer and the microscope eyepiece. The polarizing elements were rotated to produce the most vivid and striking colors.

The specimens were all prepared without cover glasses. In the case of specimens mounted with cover glasses, it is advisable to use a colorless mounting medium if possible. Furthermore, when an oil immersion objective must be used, a colorless immersion oil is recommended. The use of these materials will help to reduce the problem of color compensation.

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"BIOLOGICAL ABSTRACTS"

By STANLEY TRUMAN BROOKS

THE spread of Christianity and the pursuit of scientific knowledge were the first two fields of human endeavor to realize the global aspect of their labors. In nations politically isolationist and narrow in their humanitarian efforts, students of science found that only through cooperation with their fellow students could man progress. This early united nations' effort weathered wars, disasters, the rise and fall of kingdoms, and the economic fluctuations of a growing world. Science, as does Christianity, was found to transcend all barriers—to embrace all races, all colors, all creeds.

Strange as it may seem to the peace-loving student *Biological Abstracts*, the world's largest abstracting service to the biological sciences, was born of the confusion and catastrophic scenes of World War I. Prior to that time the American and European student depended largely upon the German abstracting organizations for knowledge of their co-workers' advances and discoveries. Naturally, therefore, when that early Axis rent asunder the channels of information, America was truly isolated from all the scientific knowledge of over half of the world. This condition stirred the students of America to discuss their predicament and to take steps to mitigate their circumstances.[1]

As a result, in 1922 there gathered in Washington the appointed representatives of 19 national biological societies who, with similar groups from the National Research Council and the American Association for the Advancement of Science, conceived and dedicated the institution which became the international *Biological Abstracts* in 1926.

Scope of the Field. No one can say what the scope of the field was 20 years ago when *Biological Abstracts* came into existence, and even today, with all the developments in transportation and communication, obscure publications of some years' standing are only now being discovered by American and European students.

One can safely judge, however, that there were probably some 50,000 printed articles describing and reporting biological research each year as well as the issue of several thousands of books. These articles were printed in possibly 30 languages and in the majority of cases were confined in their distribution to their own geographical areas; only a small proportion of this world-wide literature was available in a few of the larger libraries of each country.

At the outbreak of World War II there were at least 6,000 research periodicals and journals containing some 60 to 70 thousand articles annually.

Because of this tremendous volume of research and because of the language barriers, no investigator could keep himself abreast of his own field unless he had access to the knowledge in abridged form. No library in the world is large enough to contain all this annual accumulation of knowledge, or if there were one of that size it would be unavailable to most students.

With the end of World War II there have been some fatalities among the research journals of the world, but these eliminations are far outnumbered by the increase in publications in the newer fields of research stimulated by wartime

[1] *Abstracts of Bacteriology*—1917; *Botanical Abstracts*—1918. These first abstracting groups merged with *Biological Abstracts* in 1926.

needs. Even in some of the European countries, overrun and despoiled by Hitler and his armed hordes, new publications are appearing, and announcements have been made to *Biological Abstracts* that research which progressed even under the shadow of the Gestapo has been preserved and results will now be published. Chinese publications are planning to resume, and scientific life stirs anew in all Asia.

The Philosophy of Biological Abstracts. Abstracts are a means of mobilizing man's knowledge. Perhaps the greatest impediment to the advancement of science today is the lack of effective means by which the findings of the scientists of all nations can be mobilized, brought to the attention of students, and put to work for humanity. The philosophy is purely one for human advance and is therefore universal.

The abstracting journal is perhaps the only method by which the student today can compensate for the deficiencies of research libraries. With the exception of a few major institutions, the biological libraries of our colleges, universities, and research organizations are pitifully inadequate. Capable students are being handicapped over all the world with a resultant inestimable loss to mankind.

Scientific history, although comparatively youthful, has many instances in which the world has waited for decades for information that might have changed history were it known. A classic example is the discoveries of the Austrian monk, Gregor Mendel, whose genetic findings, published in Brünn in 1865, were only realized when rediscovered by students at the end of the century.

This is part of the picture and the basis upon which *Biological Abstracts* has taken the initiative in the establishment of its world-wide system of cooperation among biologists. Through the contributions of students in nearly every nation on earth *Biological Abstracts* has become one of the largest cooperative enterprises ever instituted by a scientific group.

The Abstracting Mechanism Today. Biological Abstracts today is housed on the University of Pennsylvania campus where it was located at its inception. However, the organization has created such widespread interest amongst educational institutions that it has received invitations to establish its activities at Yale, Princeton, and other universities.

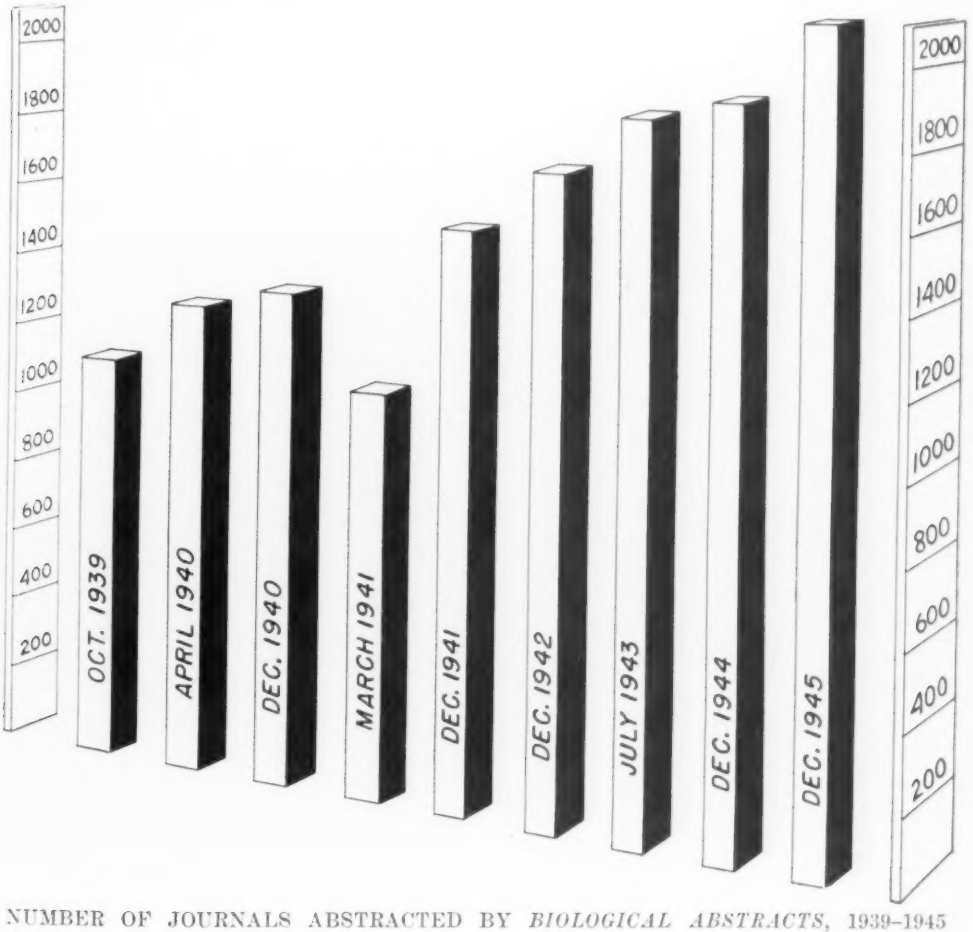
The staff of 19 salaried employees, under the direction of Dr. John E. Flynn, receive, translate, index, edit, and make ready for publication abstracts from 2,113 journals (as of December 1945), prepared by over 3,000 volunteer abstractors in America, Europe, and in every Asiatic area supporting research activities. Today that is nearly every political division on the face of the earth, and the number of sources is growing daily. The policy of *Biological Abstracts* has been, insofar as possible, to have the literature of every part of the world abstracted by workers in the country of origin. Although surrounded by combatant nations, Swedish, Swiss, Portuguese, and Turkish biologists, and those of the Latin-American nations were active throughout the recent war, and today in increasing numbers scientists from the occupied areas and those of the British Empire cooperating in this work have been able to get back to their labors of peacetime. This brings an expectancy of at least four years of accumulated research knowledge in the nearly 3,500 periodicals abroad which have not been available during that time. However, because of monetary, labor, and material shortages in many of the countries involved in the war their stock of publications will be too small to meet the demands of their fellow scientists elsewhere. Unless some form of reprint-

ing is attempted, Dr. Flynn has announced, many American and foreign libraries will be incomplete; therefore, the necessity of abstracting this material is greater than ever before. Truly an enormous task faces this abstracting organization today if this biological knowledge is to survive.

An attempt is being made to obtain authors' abstracts from as many journals as possible. At the end of 1944 about 250 such publications were being abstracted in this manner. The abstracts in each field of endeavor, however, go through the hands of the section editors, of which there are 157 covering all fields involved, before their final processing by the central office staff.

Index entries, as has been the policy of the organization, are written by students conversant with the individual field of study being indexed. About 20 to 25 persons are employed in this work and are selected from faculty and research groups. This means that a parasitologist is responsible for the parasitological studies, a forester for the ones on forestry, a geneticist for the articles on genetics, and so on.

A better conception of what this labor means might be had from the 1945 activities of the central office alone. It



NUMBER OF JOURNALS ABSTRACTED BY *BIOLOGICAL ABSTRACTS*, 1939–1945

TEMPORARY DECREASE IN 1941 OCCURRED PRIMARILY BECAUSE OF UNAVAILABILITY OF EUROPEAN JOURNALS. NEW LATIN-AMERICAN PUBLICATIONS ACCOUNT PARTLY FOR INCREASING COVERAGE SINCE 1941.

received and edited 24,221 abstracts—and this in a war year; sent 1,431 messages to collaborating scientists; invited 1,529 other workers to cooperate in the work; to work out assignments, 1,010 messages were written; 427 new journal assignments were made; 193 journals were requested from various sources, and 95 additional journals were received. This was the work necessary in addition to the formation of the 10 yearly editions of abstracts, preparing the index volume for the year, and the additional required handling of the various separate sections—a new service instituted under Dr. Flynn's direction.

This latter service now makes available to students all the abstracts in their especial fields at a nominal cost. Before this was accomplished many scholars and smaller institutions could not afford the yearly edition and were thus prevented from taking advantage of this keen research tool. An important achievement of 1945 was the establishment of a new section, "Abstracts of Human Biology." Already widespread interest and support of the new venture has made the financial success of this section highly probable.

Future Aspects of Abstracting. A man of vision as well as one of action, Dr. Flynn, if asked what his future plans were, might simplify his answer to: "Today we are covering 50 percent of the research journals and sources in the world. That half includes, however, 90 percent of the outstanding and important sources. I want to see that 50 percent become 100 percent."

That answer speaks for itself. Any editor or director would want to extend the coverage of his publication. But further investigations exposed even more of Dr. Flynn's dreams of the future. To him as well as to most scientific students war is a disaster necessitated only by man's ignorance and greed. The war, however, has opened new channels for *Biological Abstracts*, Dr. Flynn said.

Enormous fields in visual education, in public health, in the biological aspects of war material, and in the newly developed physical and chemical aspects of biology now make imperative a broader and more inclusive coverage by *Biological Abstracts*.

In this he referred to the recent Army and Navy quartermaster studies of "tropicalization," which include and utilize biological knowledge. The experiences of both the Army and Navy ordnance departments in related studies he also included.

"The useful field of biological science has grown tremendously with the war years."

Medical biology, long so well known by the investigators of the tropics, now has assumed larger proportions in the northern countries and will demand more and more space in the research literature of tomorrow. This is another field that will lay still further burdens upon the abstracting services.

But Dr. Flynn and his associates are not worried about the word "burden." It does not have the accustomed connotation to them. It only adds up to the term "better coverage," the 100 percent mark at which they are aiming.

To prove this, another innovation came to the pages of *Biological Abstracts* during 1944. This was the abstracting of biological films. Today that service is limited to three fields: microbiology, immunology, and public health. The results have already brought requests for a broader coverage. Dr. Flynn now plans to extend the service, "when possible, to all biological films, of which there must be thousands available in the universities, colleges, research institutions, industries, and government agencies." This would also include, if possible, Army and Navy training films touching upon biology.

But his plans do not stop there.

"How about the availability of the material already available?" he was asked.

Dr. Flynn adds to this apparent confusion of words by saying, "It must be more available."

But this is what he meant:

Through the use of facilities now made possible through developments in the physical sciences—photocopying, electromagnetic recording, offset photolithography, and others—the dream of 100 per cent coverage can come true. It *can*, but will it? The answer depends upon the kind and amount of support *Biological Abstracts* receives.

Through modern methods the entire 19 volumes of *Biological Abstracts* printed over the past 20 years could be published in handbook size and distributed to all research students in the world for a very nominal sum. This would make this invaluable research tool available even to the beginner in science—the junior and senior students of the colleges and universities. This will become increasingly imperative because, for the first time in the history of the world, Dr. Flynn says, the furtherance of science is conceded to be an issue of national concern.

The publication of the report of the Bush Committee *Science, the Endless Frontier* and the introduction into Congress of legislation providing for a National Research Foundation are some of the events which have brought the new status of science into the nation's consciousness. It is recognized that science must advance at an ever-accelerating pace. The nation's welfare requires this.

At the same time, the adequacy of all the existing agencies that have to do with the prosecution of science is being seriously questioned. The new mood of the nation is one that inquires, Will the agencies that have been developed in the past prove adequate for the future? Can science, in its maturity, be adequately served by those agencies that were built up in the years of its infancy and early growth?

. . . While we may look with some satisfaction on what has been accomplished by *Biological Abstracts*, it is, after all, but a beginning. The world of scholarship is demanding that its service agencies, in the postwar era, shall more than keep pace with the development of science. Expansion toward absolute completeness in the coverage of the literature, and greater promptness, and greater efficiency in use will be demanded. Fortunately, *Biological Abstracts* is well equipped by experience to satisfy these demands. It does, however, present us with an opportunity and a challenge greater than this organization has so far faced.

Thus concluded the director and editor of science's greatest service to the biological sciences.

THE NATURAL HISTORY OF YELLOW FEVER IN COLOMBIA

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THIS article is written to illustrate a thesis: that in many situations the terms "epidemiology," "ecology," and "natural history" are equivalent, and that substitution of the terms may result in a gain in understanding. The term "epidemiology" got its start quite naturally from the study of epidemics, but the concept has gradually broadened from its origin in epidemic statistics to cover the general study of the distribution of disease—of the mechanisms of maintenance and dispersal of the causative pathogens. In this sense the etymology of the word has become a handicap—the inclusion of the *demos* (people) seems to require the fabrication of parallel concepts of "epizoology" and "epiphytology" when the host of the pathogen is an animal or plant. This sets man off from the rest of nature in a compartment that may have religious value but that otherwise seems meaningless, and the student must jump between the sciences of epidemiology and epizoology, depending on which host his pathogen happens to select next. It would seem more logical to ignore the howls of the classicists and write about the epidemiology of distemper in dogs. A few daring souls have taken this step, and I was cheered the other day to find a reference to the "epidemiology of soil-borne disease in crop plants."

Epidemiology in this broad sense could almost be defined as the "ecology of pathogenic organisms," and both ecologists and epidemiologists are becoming increasingly aware of the similarity of their points of view. The maintenance and dispersal of pathogenic organisms involves factors of environment and of population dynamics that are clearly also the raw material of ecological investigation.

The outstanding English ecologist Elton pointed out many years ago that ecology is little more than a new term for the very old subject of natural history. The modern development of ecology merely reflects the fact that our knowledge of the physiology and classification of organisms only recently reached the stage where the collection of field observations, largely abandoned during the latter part of the nineteenth century, again acquired significance. But the term "ecology" often seems to imply purely the field study of the environmental relations of organisms; and the corresponding laboratory analysis of animal behavior and of the effect of environmental factors on organisms is very generally classified under the separate heading of "physiology." Studies in both the laboratory and the field are surely necessary for an understanding of the interrelations of organisms and environments, and it seems to me that this broad point of view, which reflects in a way the unspecialized attitude of the early biologists, is appropriately covered by the term "natural history."

If we make our substitution of terms —from epidemiology to ecology to natural history—we come out with an expression, "the natural history of disease," which necessarily implies a broad point of view. It could be taken to involve an interest in the pathogen itself, in the host relations of the pathogen (which result in the disease), in the environmen-

tal relations of the host which often so strikingly affect the pathogen and the course of the disease: in short, an interest in the interplay of factors involving pathogen, host, and external environment. The importance of this point of view is particularly clear in diseases involving vector relations or an alternation of hosts; and the point of view becomes a necessity when the disease is set in the tropical forest. All of us working on yellow fever have become naturalists of a sort, willy-nilly, from sheer force of circumstances. But the point of view might be equally valuable, though less obviously so, in a study of measles.

Not many years ago we thought we knew all of the essential facts about yellow fever. It was a purely human disease transmitted by a domestic mosquito (*Aedes aegypti*) and maintained by large concentrations of human populations in environments favorable to the development of the mosquito (tropical cities), occasionally spreading as a fearful epidemic to peripheral environments (northern cities). There was much evidence indicating an African origin of the disease—the vector mosquito, in particular, was apparently an African insect introduced into America with the slave trade or traffic from the Mediterranean. The urban aspect of yellow fever was most pronounced in the New World, and everything seemed to indicate that a sufficiently energetic and well-planned campaign of mosquito control in the major cities of tropical America, which appeared to be the centers of dispersal, would eliminate the disease from this hemisphere. The Rockefeller Foundation embarked on an ambitious project of study and control with this objective clearly in mind.

One could probably draw a moral of some kind from the history of this Foundation project. It ended by demonstrating that the original objective—the elimination of yellow fever from America—was impossible; after twenty years of continuous study by groups of investigators in Africa, Brazil, and Colombia, the clear concept of yellow fever epidemiology that prevailed in 1925 has become as extinct as the dodo. Any statement of yellow fever epidemiology made today is an ungainly construction, tacked together with words like "probably," "possibly," and "very likely." Yet, by a process that could hardly have been foreseen in 1925, yellow fever has been reduced to one of the most completely preventable of human diseases. The Foundation project is probably one of the most successful of large-scale, organized attacks on a medical problem—though the success was not according to plan. It might be called an accident, since the actual shift in virus pathogenicity that resulted in the vaccine strain (17D) seems to have been a random occurrence not repeatable at will—but the accident would not have occurred without the plan.

The story of yellow fever vaccine is irrelevant to our present thesis, though its development is closely interwoven with the change in our concept of virus epidemiology. The great step in taming yellow fever was of course made by Reed, Carroll, Agramonte, and Lazear in 1900 with their justly famous experiments demonstrating transmission by *Aedes aegypti*. Further work was almost impossible because of the lack of a suitable laboratory animal, and a search for such an animal was the first item on the Foundation research program. The discovery in 1927 by Stokes, Bauer, and Hudson of the susceptibility of the Indian rhesus monkey to the pathogen of the disease was perhaps the next great advance. It resulted almost immediately in many basic discoveries: the clear demonstration by Sawyer and his co-workers that the causative pathogen was a virus; the discovery by Max Theiler (at that time working outside of the Foundation

group) of the susceptibility of the white mouse, which at once became an invaluable tool; the demonstration by N. C. Davis and others of the susceptibility in varying degrees of many South American monkeys, and of the fact that many mosquitoes besides *Aedes aegypti* could transmit the disease under laboratory conditions. The demonstration by Theiler of the modification of the virus by brain passage in white mice at once gave impetus to attempts to develop a strain nonpathogenic for man that could be used as a vaccine; the successful conclusion of this study was announced by Theiler and Hugh Smith in 1937.

It is difficult for those of us who started working with yellow fever after the development of the vaccine to realize the hazards that were faced in those earlier studies. A very high proportion of the investigators contracted the disease, despite the most elaborate precautions, and several died. The immunization of laboratory personnel by the simultaneous inoculation of "fixed" mouse virus and immune serum was started in 1931 by Sawyer, Kitchen, and Lloyd, and in 1936 the much simpler vaccination with the nonpathogenic 17D strain was introduced. Since 1931 there has been no case of laboratory infection, although the number of people working with the virus has increased tremendously. The virus is handled with the nonchalance that would characterize studies of *Bacillus coli*. It is dangerously safe since one must be constantly alert not to allow the development of careless habits that might be carried over into work with some other pathogen not so thoroughly tamed.

Epidemiological studies were also being carried out through all of this period concurrently with the laboratory work, and these were greatly facilitated by two new tools. First, the discovery of the susceptibility of the white mouse made available a cheap and easily handled animal for neutralization, or protection, tests—for surveys of immunity in human or other populations. Postinfection immunity to yellow fever is lifelong in man, and the presence of such immunity can be determined by a simple test involving the inoculation of a mixture of the human serum and virus in mice. By means of such "protection test" surveys, the distribution of immunity to yellow fever—which means the distribution of individuals who have at some time been infected—can be determined; an idea of the intensity of regional infection can be obtained from the proportion of immunes; and an indication of the time when yellow fever was last present in an area can be obtained from the minimum ages of individuals showing immunity. If children show immunity, the disease has clearly been present in the population in recent years.

The second new tool of the epidemiologist is called the "viscerotomy service." It was long ago discovered that the human liver shows a characteristic pathology in fatal cases of yellow fever; since isolated cases of such a disease may be difficult to diagnose, pathological examination of post-mortem tissues may become an important factor in deciding the nature of a particular infection. Workers in Brazil developed a simple instrument, which they called a "viscerotome," for rapidly removing a small piece of liver tissue from a cadaver without undue mutilation—an instrument that could be handled by persons with no medical training. By establishing a network of posts through Brazil so that liver tissue could be obtained from large numbers of persons dying of acute febrile illness, a method was at hand for checking on the incidence of deaths from yellow fever even in areas where no medical service was available.

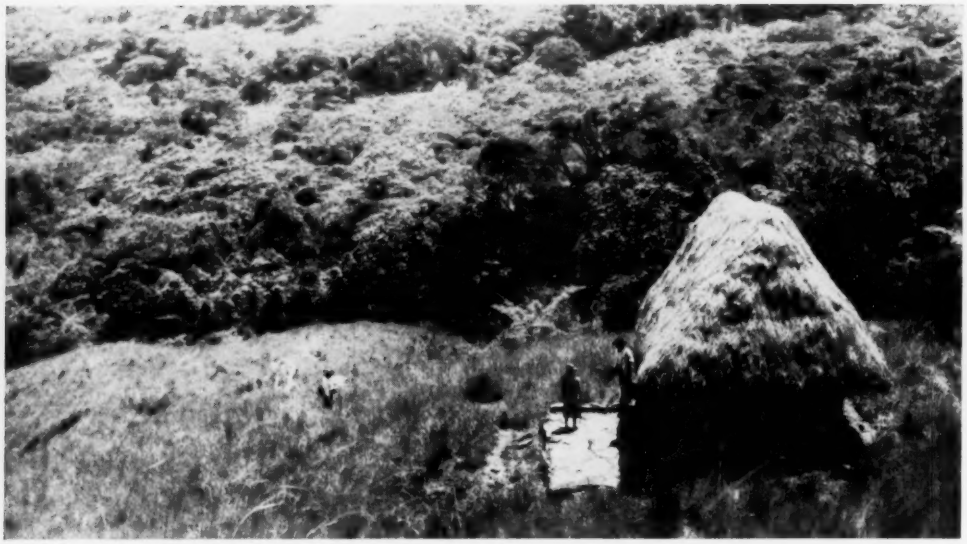
Immunity surveys and pathological examination of the material submitted

by the viscerotomy posts revealed that yellow fever was much more widespread in Brazil than had previously been supposed. At about the same time that this discovery was made, urban epidemics occurred in certain parts of Brazil and Colombia under conditions where the source of the virus could not be determined—unless it had come from sparsely inhabited forested areas, which was in conflict with what was known about the epidemiology of the disease. It was also discovered about this time that yellow fever was present, and had been present for many years, in certain parts of Colombia where the known vector mosquito *Aedes aegypti* did not occur. All these things together led to the development of the concept of "jungle yellow fever"—of yellow fever continuously present in the forest, occasionally and fortuitously infecting man, and occasionally reaching towns and cities where it could be picked up by *Aedes aegypti* and converted into the classical urban disease. Studies of the possible mechanisms of maintenance and dispersal of this forest yellow fever were started in Brazil and Colombia in 1934; and in 1938 a well-equipped virus laboratory was installed at Villavicencio in eastern Colombia for the express purpose of studying the epidemiological aspects of this disease.

The presence of yellow fever in the Villavicencio region first came to medical attention in 1934, but there is every reason to suppose that it had long been present in the area, undiagnosed. Careful studies over the next three years revealed many clinical cases of yellow fever, always in persons with some history of contact with the forest: usually woodcutters or farmers clearing land, occasionally people with more casual contact with the forest such as a child who had carried lunch to a father at work. There was no hint of man-to-man transmission by domestic mosquitoes, and in fact *Aedes aegypti* was found to be completely absent from the region. Townspeople who stayed out of the woods were apparently perfectly safe. A similar situation was found in other parts of Colombia, notably in the region of Muzo where the emerald mines are located. Villavicencio was selected as the site of the laboratory largely because an automobile road was completed across the Andes in 1937, making the town relatively accessible.

The first two years of the life of the Villavicencio laboratory must have been very discouraging, because not a single proven case of yellow fever turned up in the region. Cases had been found every year previously and have been found every year since except for the year 1945. For the absence of the disease during 1945 we believe we have an explanation: the severest dry season of which we have a record resulted in the complete disappearance of vector mosquitoes from our study areas, and we think the virus may have died out and that it will take time for it to filter back from the regions of more constant rainfall to the south of us. Something of the sort may have happened in the dry season of 1937–38, but comparisons are difficult because a standardized system of weather and mosquito records had not yet been installed. The investigators at Villavicencio during that period put their time to very good use, however, in making laboratory studies of the susceptibility of animals of all sorts—mosquitoes, ticks, reptiles, birds, mammals—and in perfecting techniques of study. When the first human cases were discovered in 1940, they were thus ready to take maximum advantage of the occurrence.

The law requires that a representative of the laboratory must sign the death certificate before any corpse can be buried in Villavicencio. If the case history shows an acute febrile illness with



THE COLOMBIAN FOREST—HOME OF HAEMAGOGUS MOSQUITOES

A WOMAN WHO LIVED IN THIS HUT DIED OF YELLOW FEVER; SHE WAS ACCUSTOMED TO WASH CLOTHES IN A STREAM AT THE MARGIN OF THE FOREST WHERE HAEMAGOGUS MOSQUITOES WERE ABUNDANT. THE COUNTRY PEOPLE OF EASTERN COLOMBIA GENERALLY LIVE THUS, IN CONTACT WITH THE FOREST.

onset of symptoms less than ten days before death, a liver specimen is taken by means of the viscerotome for pathological study. In this way quite a few otherwise unrecognized cases of yellow fever have been discovered. The local physicians are also very cooperative and call attention to any case that might be yellow fever. When such a case is seen, if the patient's blood smear is negative for malaria, blood serum is inoculated into mice to attempt isolation of yellow fever virus. Yellow fever is a disease of country people, and these people do not come into town for medical assistance unless they are very sick indeed; if the infection is yellow fever, "black vomit" (from stomach hemorrhage) has usually set in, and there is little doubt about the diagnosis. And the prognosis, as the medicos would say, is very unfavorable.

The method, when there was strong reason to suspect a case of yellow fever, was to question the man or his family as to his movements during the week previous to the onset of symptoms. Almost always the individual had been working in some specific patch of forest during this time, either clearing land or lumbering. Sometimes this patch of forest was a day or more away from the laboratory on horseback; in a few instances, it was within half an hour or so of the laboratory and easily reached by car. In either case, an intensive study was made of that particular patch of forest in an effort to localize the source of the virus. A camp was established when the forest was not within easy reach of the laboratory, and all of the apparatus necessary for a field study of virus was carried in: cages of white mice and monkeys, sterilizing equipment, and glassware, as well as the normal supplies necessary for any isolated encampment. This work was largely carried out by Dr. John Bugher and Dr. Jorge Boshell-Manrique, both equally at home in the forest or in the laboratory and both of whom had the "natural-history" point of view as defined at the beginning of this article.

The results that had been accumulat-

ing both in Brazil and Colombia indicated that the mechanism of yellow fever maintenance in the forest was probably a mammal-mosquito cycle, and efforts in these field studies were largely concentrated on attempts to isolate virus from mosquitoes and to determine the extent of immunity (indicating previous infection) among mammals. One particular mosquito, a bright metallic blue species called *Haemagogus capricornii*, was early suspect both in Brazil and Colombia. Many attempts were made to transmit virus with this mosquito in the laboratory, but with little success. The mosquitoes were very difficult to keep alive under laboratory conditions, and even when they could be kept alive for what seemed an adequate period, transmission did not occur or was irregular. Yet the mosquito was always turning up where there was sylvatic yellow fever, and in 1938 workers in Brazil recovered virus from wild caught specimens of this species.

Dr. Boshell made a basic discovery about this mosquito very early in these field investigations. He had gone into patches of forest where men who had been felling trees had contracted yellow fever and yet he had found very few mosquitoes. The men claimed that they had been pestered with clouds of mosquitoes while working, and one day he accompanied such a group and found that this was true: mosquitoes would be scarce in the undisturbed forest, but as soon as one started to fell trees, they appeared in great numbers—mostly haemagogus. They were activated by disturbing the forest. For a while he tried deliberately felling trees to get mosquitoes for virus studies; then he started wondering where the mosquitoes were before the trees were felled. I do not know where or exactly when he first climbed a tree to look for haemagogus, but it was not long before he had his answer: the mosquitoes were normally in the forest canopy and came down to bite in large numbers only when the forest was disturbed. By climbing into the canopy they could always be found.

From that time on, haemagogus could be collected in large numbers in these areas where yellow fever was contracted. Many thousands were inoculated into mice and monkeys, and during a year of work virus was recovered from such mosquitoes on thirteen occasions. The prime requisite for a study of the epidemiology of yellow fever became agility at climbing trees, and it was increasingly clear that the habitat of the disease was the forest canopy. We now understood why yellow fever in eastern Colombia could be characterized as "an occupational disease of woodcutters."

At this point yellow fever again became a laboratory problem: there was ample evidence from field studies that the haemagogus mosquito was the main vector of yellow fever in the area, yet attempts to obtain transmission under controlled laboratory conditions continued to give negative or anomalous results. Haldane has remarked somewhere that biological research consists of "asking nature simple questions one at a time." The work had reached the point where we could frame our questions in fairly simple terms and take them up one by one. First, there was the question of how to keep haemagogus alive in the laboratory long enough to carry out adequate transmission experiments. We worked on this off and on for two years, with a notable lack of success. Our experiments are perhaps worth mentioning as a fine example of human failure to add up an obvious two and two. We were making rather detailed ecological studies of haemagogus behavior in the forest, and for this purpose we built ladders and platforms in trees, making observations on the vertical gradients in temperature, humidity, and light and collecting statistics on the

THE FOREST FLOOR

RECORDS ARE MADE HERE OF ENVIRONMENTAL CONDITIONS IN THE FLOOR ZONE OF A STUDY AREA NEAR THE LABORATORY AT VILLAVICENCIO.

occurrence of haemagogus with relation to these gradients. We had thermographs at different levels and in general learned a deal about the physical environment of the forest. We of course studied conditions at ground level as well as in the canopy; and for those first two years we continued to think of this ground level environment as the total forest environment and to try to reproduce ground level conditions for maintaining our mosquitoes in the laboratory. We knew haemagogus avoided the ground level in dense forest but we failed completely to make the obvious deduction from the field to the laboratory, even though these studies were being carried out by the same people at the same time.

One trouble was that our methods were conditioned by previous work on anopheline mosquitoes. Anophelines fly at night and generally seek some cool, dark resting place in the day: in the laboratory they should be kept in a cool and moist environment for maximum longevity. The ideal place to keep anophelines is in a cellar. We dug a cellar, fixed it up with time switches for controlling light cycles, and achieved a splendid reproduction of conditions prevailing at ground level in the forest. Anophelines were perfectly happy in this cellar, but haemagogus died off within four or five days.

We were at the same time trying to find some way of getting large numbers of eggs from haemagogus. We again tried an anopheline technique—putting individual mosquitoes in small shell vials with a moist filter paper pad in the bottom. Haemagogus responded well to this treatment, laying good numbers of eggs. I think again it was Dr. Boshell

ABOVE THE FOREST FLOOR

THIS PLATFORM IS FOURTEEN METERS ABOVE GROUND LEVEL, OVER THE THERMOGRAPH STATION OF THE PRECEDING PHOTOGRAPH. HAEMAGOGUS MOSQUITOES ARE ABOUT FIVE TIMES MORE ABUNDANT HERE THAN AT THE GROUND.

who first noticed that mortality was surprisingly low in these vials and who first thought of trying to use the vials for maintaining haemagogus. To get eggs rapidly, we kept the haemagogus in an incubator which had an electric fan built in to avoid air stratification. The haemagogus lived beautifully in this incubator, so it seemed that the proper technique with haemagogus was to keep them warm and dry; in other words, to reproduce the physical conditions found at midday in the forest canopy, not those found at ground level.

We continued trying to make laboratory transmission experiments at the same time that we were learning how to keep the mosquitoes alive for longer periods. There were many other difficulties, and one of our biggest needs was large numbers of some suitable experimental mammal from the local fauna. The rhesus monkey remained the standard animal for yellow fever experiments after the discovery of its susceptiblity by Stokes, Bauer, and Hudson; but rhesus were difficult to get in wartime, very expensive at any time, and experiments with an exotic mammal could not be interpreted in terms of local epidemiology. The immunity surveys of local mammals had shown positive results among many different species, more especially species of marsupials and primates. We spent a year working on the marsupials, trying to use them as source animals for mosquito infections, before giving up and starting on the local monkeys. One of these monkeys, the saimiri, had been found to be very susceptible many years before by N. C. Davis, working in Brazil, so this species was tried first. We found that it circulated large amounts of virus regularly, often showed clinical symptoms of illness, and frequently died in the course of infection. It seemed to be an excellent laboratory animal. It took a year of propaganda to get the local people to catch them in quantities, and they got in the habit of selling us monkeys just about the time we were really ready to make use of them.

TREE CLIMBING

THE LABORATORY STAFF HAVE BECOME EXPERT AT BUILDING LADDERS IN TREES; THE LADDERS ARE MADE IN FOUR-METER SECTIONS AND ARE THEN NAILED TO THE TRUNK. THIS PARTICULAR TREE IS USED FOR THE STUDY OF MOSQUITOES BREEDING IN A SERIES OF CAVITIES IN THE TRUNK.

Even with these monkeys, haemagogus did not transmit virus regularly. We thought there might be something wrong with our virus strains, which had been subject to a lot of unnatural laboratory manipulation in the course of the exploratory experiments. Sporadic cases of yellow fever were continuing in the area, and it was fortunately possible to obtain two new strains. We obtained one of these strains very conveniently right in the laboratory. A man came in one day with a note for Dr. Roca from one of the town physicians, who

A SUSCEPTIBLE MONKEY

THE SAIMIRI MONKEY (*Saimiri sciureus caquetensis*) IS THE MOST ABUNDANT PRIMATE IN THE VICINITY OF VILLAVICENCIO AND IT IS VERY SUSCEPTIBLE TO THE VIRUS OF YELLOW FEVER.

was puzzled as to the nature of a skin rash and wanted Roca's opinion. Roca questioned the man and learned that he had come to town because his brother, with whom he had been working in the forest, had died a few days before with "black vomit," scaring him sufficiently to make him think of making the long trip for vaccination. He had a slight fever and headache, a slow pulse, and yellow eyeballs. Roca, in the course of his years of study of yellow fever in the region of the emerald mines, had seen an immense number of cases of all grades of severity, and he suspected that the man might be infected. He took a blood specimen, which was inoculated directly into a saimiri monkey, and recommended to the man that he go back home to bed. The monkey died nine days later and served as the source animal for a strain of virus that was kept constantly going in the laboratory by haemagogus transmissions from monkey to monkey for a year. The man, we learned later, did not follow Roca's advice about going to bed; his headache got better in a day or two, and he went back to work. Roca got hold of him again a month later to make a blood test for yellow fever immunity (he had not been vaccinated after all), and this later sample showed clear protection for yellow fever, in contrast with serum saved from the sample taken at the time he appeared in the laboratory.

With these new virus strains and with the new handling of haemagogus, there was no trouble at all in maintaining transmissions in the laboratory. We were able to study the effect of various factors on virus development in the mosquitoes, and one of the most important and most interesting of these factors

A SUSCEPTIBLE MARMOSET

THIS MARMOSET (*Oedipomidas oedipus*) REPLACES THE SAIMIRI MONKEY IN SOME PARTS OF COLOMBIA WHERE YELLOW FEVER IS ENDEMIC; ALL THE MARMOSETS SEEM TO BE VERY SUSCEPTIBLE TO THE DISEASE, AND STUDIES IN BRAZIL INDICATE THEY ARE IMPORTANT HOSTS OF THE VIRUS OF SYLVATIC YELLOW FEVER.

proved to be environmental temperature. If the mosquitoes were kept at a constant temperature of 25° C., few became infected, and the incubation period of those few was greatly prolonged. If the mosquitoes were kept at a constant temperature of 30° C., a very high proportion (usually all) became infected, and the incubation period might be as short as ten days. Constant temperatures of 30° C. are unknown in our forests, so we started testing alternating temperatures. We found that twenty hours a day at 25° and four hours at 35° gave almost as good results as the constant temperature of 30°, as far as virus development was concerned, and that the mosquitoes subject to such alternating temperatures survived for very long periods—forty or fifty days quite commonly. If kept at a constant temperature of 35° C., they lived for only a very few days and they must have been subject to serious physiological disturbance since they laid no eggs and were induced to feed again only with difficulty. To study the effect of temperature, a group of mosquitoes that had fed on a given infected monkey would be divided at random into several lots, which were kept under the conditions to be tested; we were thus sure that the condition of infection of the mosquitoes was uniform. One such group that was divided into five lots maintained at different temperatures and tested for transmission every day gave the following results:

Temperature Condition	First Transmission
Constant 35°	No transmissions
Constant 30°	10 days
20 hrs. 25°, 4 hrs. 35°	12 days
20 hrs. 25°, 4 hrs. 30°	23 days
Constant 25°	28 days

In other words, four hours' daily exposure to the (for a mosquito) very high temperature of 35° brought the virus incubation period down to a reasonable length of time. We have never found a shade temperature of 35° in our forests, but the bright blue haemagogus are often found in the sunlight. Various investigators have found that insect body temperatures in the sun rise quickly to temperatures in the neighborhood of 40° C., so haemagogus flying in the sunny areas of the forest canopy may well be daily exposed to fairly high temperatures. It is difficult not to believe that their metallic coloration is an adaptation to life in an environment of relatively low humidity and high temperature. The brown-and-grey nocturnal mosquitoes and the dull-colored mosquitoes of the ground level zone of the forest survive for only a few days under the laboratory conditions that we use for maintaining haemagogus; yet these dull grey-and-brown mosquitoes will live for weeks in our cellar where haemagogus die in four or five days.

MAINTAINING HAEMAGOGUS

HAEMOGOGUS MOSQUITOES ARE BEST MAINTAINED IN THE LABORATORY IN INDIVIDUAL SHELL VIALS WITH DISCS OF MOIST COTTON IN THE BOTTOM, PLUGGED WITH WIRE GAUZE; THESE TUBES ARE MAINTAINED IN A RELATIVELY WARM AND DRY ENVIRONMENT, LIKE THAT ATOP THE FOREST.

We have thus come to form a picture

of yellow fever as a disease of the forest canopy, carried on by continuous cycles among the arboreal monkeys and the canopy mosquitoes. Many local mammals can be infected with yellow fever, in the sense that some virus can be recovered in circulation after laboratory inoculation, but as far as we know only the common monkeys circulate enough virus regularly to infect these haemagogus mosquitoes. Around Villavicencio saimiri is our commonest monkey; in many parts of Brazil marmosets are the abundant monkey, and they show the same infection behavior as saimiri; in some parts of Colombia where yellow fever occurs, the douroucouli seems to be the only monkey present, but it proved to be the most susceptible of all in laboratory experiments with haemagogus. These monkeys and mosquitoes show the same ecological distribution, and the physical environment of their habitat, the forest canopy, must be reproduced if the mosquitoes are to be kept alive in the laboratory; and these same physical factors seem to be a prerequisite for virus transmission by these mosquitoes.

It is, of course, impossible to be sure that we have all of the basic facts involved in the maintenance and dispersal of yellow fever virus in the South American forest. It would not greatly surprise any of us, for instance, if someone should prove tomorrow that the virus can be maintained through transmission by some species of tick among common opossums. All the experimental work with such mechanisms has given negative results, but negative results are notoriously difficult to evaluate. We do have a working hypothesis which at the moment gives us a certain amount of intellectual satisfaction and which seems to fit the known facts—around Villavicencio at least. And this hypothesis of maintenance by haemagogus transmission among arboreal monkeys seems a particularly nice illustration of the value of the "natural-history point of view" in studies of disease: of the value of the combination and alternation of field and laboratory studies, of separate yet integrated work on the biology of the pathogen, the vector, and the host. The neatness with which the data obtained by ecological studies of the environment of the forest canopy serve to interpret the data obtained in laboratory studies of mosquito infection is especially striking; in fact, it seems too neat and simple to be true. We are sure, however, that "epidemiology" in the strict sense of the word is a meaningless term as applied to sylvatic yellow fever since the basic spread of the virus is certainly epizootic. Even a study of the "ecology" of yellow fever would have little meaning without the laboratory work on virus behavior.

It is interesting that the various scientists involved in these studies of sylvatic yellow fever started out as members of fixed professional categories, as pathologists, entomologists, or physicians. The men who made the greatest contributions, however, soon were working well outside the field of their professional classification: pathologists classifying mosquitoes, physicians trapping mammals, entomologists making studies of virus circulation in monkeys. I think no one consciously intended to study the "natural history of yellow fever"; the point of view grew out of the necessities of the subject. But in surveying the studies that have been made, the value of this point of view seems obvious, and it seems very possible that the deliberate cultivation of such a point of view in other, less obvious, situations might be productive of very worth-while results.

THE PLACE OF FEAR IN THE SCHEME OF THINGS

By A. G. KELLER
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FEAR is not a pretty thing. Nor is regret. Paradise contained neither one. Neither figures in any blueprint of a New Jerusalem. A rarity is the statesman in office who dares to forecast the genuinely fearsome; it is left to the opposition to "view with alarm." What men want is to eat, drink, and be merry. In dire peril, too imminent to be ignored, they have risen to the lift of a great Leader; but as soon as they cease to fear, they are ready to slump back into the comfort of "normalcy," relaxation, forgetfulness of experience, credulity ready to be played upon by any plausibly dressed-up Santa Claus.

The tendency of the People is to lie back after effort into an *otium*, not *cum*, but *sine, dignitate*. The higher tension of fear is too strenuous to be borne very long; and a welcome torpidity ensues upon its relaxation. The *esprit de corps* ravels out. The People repudiate their saviors when the anxiety that forces the facing of peril has been removed under heroic leadership. Let the names of Clemenceau and Churchill stand for this return to otiose "normalcy," with nothing to fear but fear.

Fear is one of those sour-faced inevitables that stir men out of their otiosity into spurts of desperate joint action. It is the prime awakener that can bring them to their senses, that can tap whatever residual common sense they possess. "Ties of common funk" have held men together in effective association, at least during a crisis-time. They may be the only effective ties, in view of the newest instrument of destruction, to bind the nations into an inclusive peace-group. The pressure of danger from without has secured an inner cohesion, as in time of war. That such unity often promptly dissolves with the removal of the fear-pressure emphasizes the truth in the case.

In general, a life without fear would resemble a railroad that has scrapped its red signals in favor of a policy of sheer recklessness. The recognition of peril causes men to try to do something about it. What they have done has generally been more miss than hit, for they have had available for long ages only the trial-and-error method. But even their random dashes up one blind alley after another, with ensuing emergence in sorry plight, have taught them one great truth: that you have first to learn where it isn't before you find out where it is.

Men learned (as they slowly and painfully explored the blind alleys and ruefully nailed up signboards labeled "No Thoroughfare") not *not-to-fear*, but *what-to-fear*. Here was a kind of breakdown of an all-pervasive general fear into its specific parts, some of which men could then learn to forecast, dodge, or even handle. Thus arrived discrimination.

To banish all fear by some formula of exorcism, or to adjure mankind to shut their eyes to it, is to challenge the historic process by which the race has been taught, by experience, *what-to-fear*. It is anxiety that has begotten caution, a corrected forecasting, the demand for a regularity that could be counted on. It has driven men to work, to save, and to safeguard by law the results of labor and thrift. Above all, it has caused them to take heed of experi-

ence, to remember and record its teachings. Fear is neither all bad nor all good; it is something very strong and inevitable, like gravitation. It is not to be thwarted by some kind of liquefaction or levitation.

Discomfort arises from maladjustment. All men's institutions—the industrial organizations, property-systems, regulative (governmental) systems, religious systems, family organizations—develop as adjustments and re-adjustments, to society's life-conditions. All of them confer a degree of regularity and security in a world of ominous insecurity and well-justified fear of misfortune. All are insurance-devices, developed very gradually and unpremeditatedly against pain and loss. Insurance is effective mainly in distributing calamity so that it can be borne by the individual, who pays for it in premiums of work, of self-denial in myriad forms, of taxes and tithes—in a general and comprehensive effort to erect bulwarks against dangers always present and always to be feared by those possessed of a grain of insight. Only the fool, together with the god who is supposed to look out for him, can be nonchalant in the case.

It would be much more agreeable on earth if fear could be dissipated by a lighthearted gesture, by injunctions of trustfulness, by a wishful optimism preached by the sincerely naive or by disingenuous exhorters with axes to grind. For fear is there, and to stay, in the Scheme of Things. Something that it is well to fear is always at hand. There is nothing for men to do except to make the best of it. The way to make the best of it is to recognize it, study it, and adjust to it. By those so doing, it can even be used to minimize the ill it threatens.

That is exactly what has been done in the case of other inalterable life-conditions: men have learned *what-to-fear* and, to some degree, how to evade it: for instance, how to deal with fire or epidemics. Consider the latter for a moment. Among savages, when several unaccountable deaths have occurred, the survivors flee the region, abandoning planted crops and other valued possessions; but in time men dared to stand fast, to hang on to their property, and to lay quarantines or use prophylactics and medicines. Except for their fright, none of these developments would have occurred, any more than with animals; the afflicted would merely have died. It is irrelevant that their fears scared them up many a blind alley; it was being thrown out that taught them the signboard habit. It is true that signboards become weathered and "old," and no longer prevent zanies from dashing up the alleys, chanting: "It will not be so this time!" The pity of it is that they so often stampede credulous innocents to go along.

Freedom from fear, as a form of general felicity, is a utopian conception, inexpedient, to judge by the experience of the race, even were it realizable. "Ideologies" that strain after and promise satisfaction of yearnings, are alluring, especially if decked out with a panoply of noble sentiments. They always lean toward universals and absolutes. But universal propositions are exceedingly vulnerable, for it takes only one single exception to ruin them; and there are plenty of places along the road toward civilization where freedom from fear would have been disastrous to all that we call "progress." Faced with exceptions, the easy generalizer of universals is obliged to wriggle: "Of course, I did not mean that kind of fear"; or to galvanize the hoary "argument" about the exception proving the rule. And as for absolutes, none exist except, perhaps, absolute nonsense.

The truth is that there are fears *and* fears. Some of them can be dissolved and some not; but no one of them flees

incontinently at even the kingly word: "Avaunt!" Fears also are like wants, in that any satisfied want merely breeds more wants, just as the lopping off of one of the Lernaean Hydra's heads resulted in several sprouting, in a geometrical progression, from the stump.

The injunction to banish all fear has been known to be nothing but a device, like the shooting of the prestidigitator's pistol, to divert attention from some trick the enjoiner is about to pull off. What that kind of injunction may mean is: "Don't fear Me"; and is often accompanied by the suggestion of new fears that shall inspire uneasiness and flight when no man pursueth. If you can get several timid souls on the run, a chase is on, even out of mere curiosity, with a lot of diversion for all hands except the goats. The invention of empty fears and the starting of a hue and cry after some selected victim are stock methods of propaganda: elderly devices, but, like Helen of Troy, seductive, even in advanced years, as ever.

The promise of something for nothing, in this case a gratis emancipation from anxiety and care, has taken in many generations of mankind, despite all warnings to fear those bearing gifts. There is a substantial ransom exacted for any genuine release from fear, namely, serious, steady, protracted effort in patient toil and study—as the accredited sciences have demonstrated; and no more is to be expected than one small conquest at a time over ignorance and in the correction of error. Never one grand leap to security by way of some proclaimed New Order of the Ages. For there is no royal road to the knowledge that alone can enable mankind to discriminate between fears: those that are fictitious; those that can be nullified in whole or in part; and those actual and durable fears that must be recognized and met by such adjustments as are possible to men.

It has been contended that anything that even only apparently and equivocally banishes fear is legitimate because it promotes confidence and makes for morale. Much has been claimed for faith, however blind. Napoleon is cited for his pronouncement that morale (spirit, *esprit de corps*) is to other military assets as three to one. Fanaticism has had its acclaimed successes all through history, and to this day. As a "shot in the arm," it has incited to what looked at the time to be astonishing and even permanent results. Its administration has been at the hand of a series of prophets who have attained to dictatorships; and some of these Leaders have lasted quite a while and have even been deified after presumable death, so that the fanaticism they inspired has survived them, having freed itself from its human origin and turned into an article of belief, pure and simple—into some kind of Absolute Faith henceforth immune from all critical examination. A Doctrine has been born which comes to be viewed reverentially (note the "fear" in the etymology of "reverence"); that is to say, it has become a thing in itself that emanates fear, a reverence for what is supposed to confer security against all other fears, including that of death and damnation.

No such faith has withstood disillusionment through experience, though the most earnest and ingenious effort has been expended in explanations, alibis, interpretations, and apologetics to prove its infallibility, and so to shore up a slipping morale dependent upon it. With disillusionment have returned, in greater strength, all the uncertitudes and fears of insecurity against which faith had decreed a permanent banishment.

As a covering illustration of the handling of fear, consider the fear of war. There is nothing that men have dreaded more, or more ardently prayed against. But wars have gone on; and the burden

of proof that they can be banished by supplication has been too heavy for any faith to bear, no matter with what agility in the invention of explanations the official representatives of that faith have been able to exhibit. In the end, all these apologetics shrivel up into: "Wars recur because they recur," which has never afforded much comfort to anybody, for it offers nothing but insecurity to count on.

It ought to have become evident, by now, that the only way to try to limit war is the way taken, after sad disillusionment, in the case of disease. There was never any prospect of banishing disease by cursing it in some grand ceremony of anathema, or by taking vows never to tolerate it, or by passing resolutions, in convention assembled, against it, or by trying to ignore or banish its characteristic symptoms—to drive in an eruption so that it is out of mind because out of sight. But that is exactly the way that frightening social maladies, of which war is only one, have been traditionally handled: by any handy magical means that could be plausibly suggested to "openmindedness," that is to say, to credulity unchecked by the common sense that, in last resort, takes painful and rueful heed of the givings of experience. Plain sense had to do that from the outset in cases where the cause-effect sequence was too obvious to be missed by minds sensitized by the nearness of peril; but it was a long time before that sequence was actually sought out and studied, when "native" common sense had been refined into the "trained and organized" common sense of science.

Here is an old, old story that has been little heeded because dull to minds fed on wishfulness, and soon forgotten. The fear of the Ways of Things, which are personified as "The Lord" or "Fate," is still the beginning of wisdom; and the only sane and safe course is to go on seriously, sturdily, studiously, honestly, courageously, from that beginning.

OREGON'S WONDERLAND OF THE PAST—THE JOHN DAY

By CHESTER STOCK

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CLEAR comprehension of the story of the past life of the earth as revealed in any one region often depends upon a succession of favorable circumstances. While it is commonplace to say that the ravages of time leave their impress on things material, they are probably never so much in evidence as in that organic record of the past scrutinized by the student of the earth sciences. Indeed, the chance occurrence of a geologic event is often responsible for those tantalizing uncertainties in paleontology which in themselves serve as incentives to read and interpret earth history.

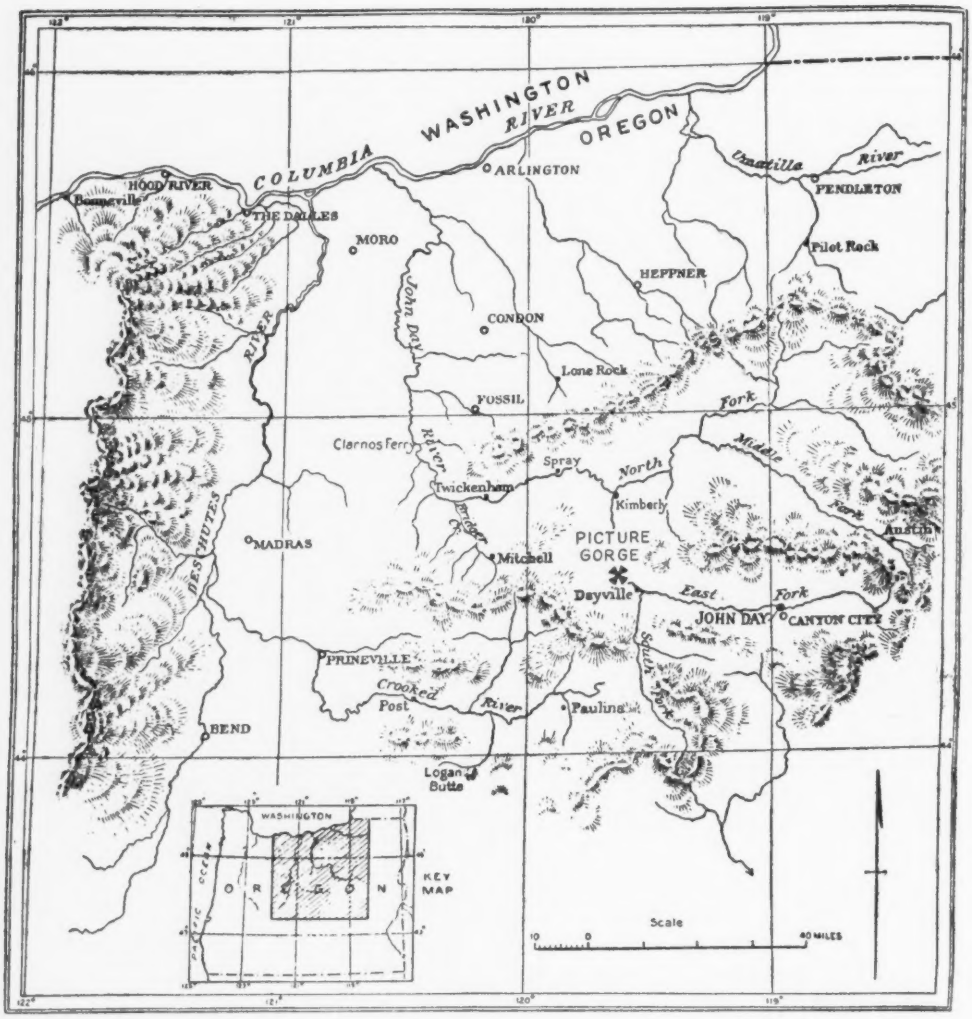
In any attempt to follow the flow of life through the geological ages on the basis of fossil remains, there must be available, first of all, an adequate amount of material, and the organic remains themselves must be sufficiently well preserved to permit a ready identification. Agencies which come into being on the death of an organism may be so destructive and may continue to act so adversely to its preservation that one never ceases to wonder at the surprisingly good quality of much of the testimony derived from the rocks.

Much less significant today than formerly is the accessibility of collecting grounds—often badlands—where this kind of fossil record is uncovered, for modern transportation and communication facilities, in our own country at least, have overcome the difficulties which most terrains offered to the pioneers and early explorers. Probably of greatest importance, however, is the requirement which certifies the position of individual stages in the historic sequence with regard to the superimposed rock formations or strata in which they occur.

Perhaps nowhere in North America are these conditions met quite so favorably, nor does a representative portion of the past history of mammalian life unfold so clearly and impressively as in the John Day region of north-central Oregon. Here, in at least five out of seven or eight readily recognizable and superimposed formations occur the skulls, teeth, jaws, or skeletal elements of extinct mammals. Complete and articulated skeletons are found much less often. But whether complete or not, these are the remains of once living creatures that date from several distinct stages in geological time.

In the millenia that have elapsed since their accumulation in the sands, gravels, muds, or ash of a former time, the sediments themselves have been compacted and hardened and more or less altered. In the course of this accumulation and alteration the organic remains have likewise undergone change. Thus the organic substances which originally made up the tissues of bone and tooth are often found to be replaced by inorganic salts like lime and silica, and this replacement has turned individual specimens more or less to stone. Petrifaction, as this mode of preservation is called, commonly characterizes the fossil mammalian material found in the John Day area and is an important factor in allowing the specimens to retain their identity through the long period of their entombment.

The strata in which this significant history of life occurs are only a part of



Modified after Chaney

THE NORTH-CENTRAL PORTION OF OREGON

SHOWING THE DRAINAGE BASIN OF THE JOHN DAY RIVER AND THE LOCATION OF OREGON'S WONDERLAND OF THE PAST. THIS AREA IN THE VICINITY OF PICTURE GORGE IS DESIGNATED BY A MALTESE CROSS.

a much thicker aggregate of rock units exposed along the John Day River and its tributaries. It becomes evident, even to the casual observer who travels the John Day highway, that the entire section of strata in this region shows noteworthy differences in types of rocks. Less apparent, but readily comprehended with a little study and contemplation, are the conditions of climate and topography that must have existed when the individual formations accumulated. The sedimentary beds that contain the petrified skeletal remains of land mammals—and impressions of plant fossils in some horizons—were apparently laid down in several ways: on the land surface; in lake basins; and under fluviatile conditions.

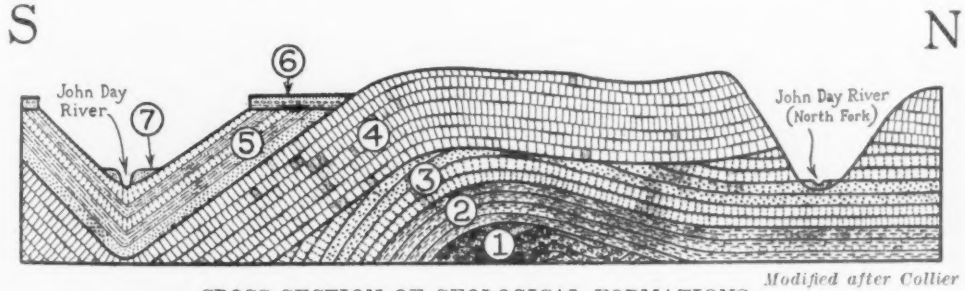
However, not all of the rocks that are seen in the John Day area originated in this manner. The Columbia basalts,

one of the most distinctive and widespread formations in the Northwest, are strikingly displayed in cross section in Picture Gorge, the canyon through which the John Day River flows, about five miles west of the village of Dayville. These rocks were once molten, and, while occasionally the charred and silicified remnants of tree trunks are found in them, no vestiges of animals have been discovered. Nor would one normally expect to find them. Again, marine deposits occur well below the Columbia lavas and are, as a matter of fact, among the oldest known strata exposed in the immediate vicinity of Picture Gorge.

Viewing the entire array of formations along the John Day River and highway from Spray southward to and beyond Picture Gorge, one is also impressed by the fact that gaps, or intervals, are present in this sequence of strata. In other words, that portion of geologic time recorded by the several rock units is not complete in the sense that the last thirty or forty millions of years of earth history is represented by an uninterrupted succession of geological formations, layer upon layer, or by a continuous sequence of life. It would indeed be remarkable were this actually the case. Instead, the periods of accumulation of sediments and lavas in this region were interrupted at intervals by earth movements of greater or less intensity. As a result, the strata that had accumulated prior to an event of this kind were folded, in some instances broken or faulted, and eroded. On the eroded surfaces were then laid down later deposits. These discordances in the stratigraphic record tend further to demarcate sharply the individual rock formations from each other and help to differentiate the fossil assemblages found in them.

The oldest mammalian fossil so far known from Oregon is a single tooth, discovered in the Clarno formation near the crossing on the John Day River called Clarnos Bridge. The Clarno deposits in this region consist of tuffs and mud flows. The specimen has been identified as belonging to an early type of rhinoceros. In the same formation occur fossil nuts, seeds, and leaf impressions.

By far the most abundant remains of fossil mammals are found in the picturesquely sculptured and often vividly colored badlands of the John Day deposits located between Spray and Picture Gorge. More than one hundred different kinds or species have been described from the John Day, the list including flesh eaters, like the true and saber-toothed cats, and a large variety of dogs, herbivores, like the horses and camels, omnivores, like the peccaries and giant pigs, and, in addition, rodents, rabbits, and an opossum. In the entire assem-



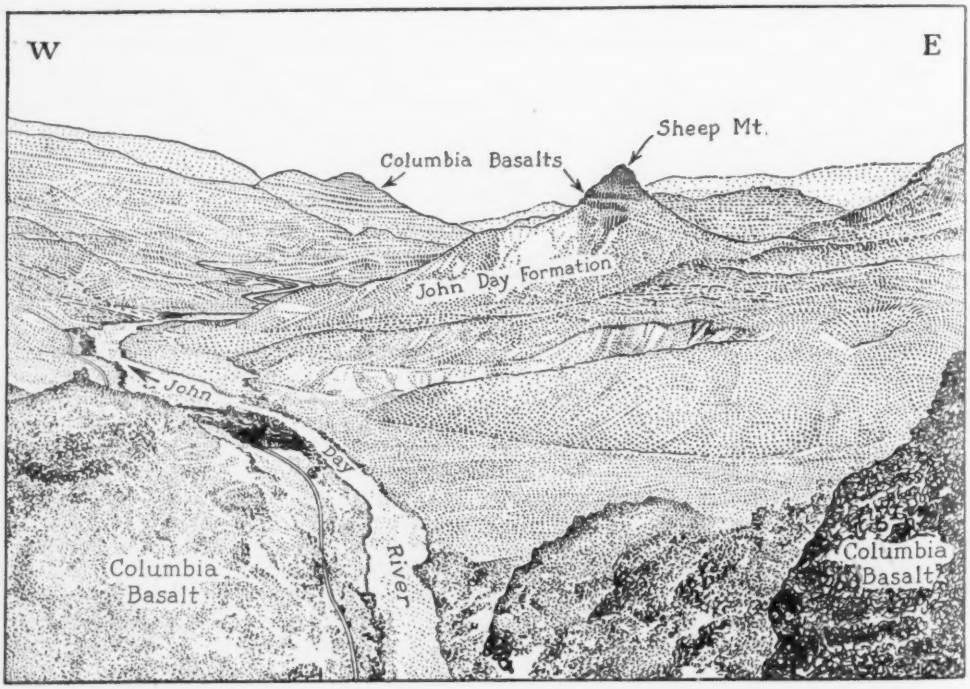
Modified after Collier

CROSS SECTION OF GEOLOGICAL FORMATIONS

A DIAGRAMMATIC AND SOMEWHAT IDEALIZED SECTION OF THE FORMATIONS EXPOSED BETWEEN A POINT NEAR PICTURE GORGE AND ONE SITUATED NORTH OF THE NORTH FORK. THEY ARE: 1, CRETACEOUS; 2, CLARNO; 3, JOHN DAY; 4, COLUMBIA BASALT; 5, MASCALL; 6, RATTLESNAKE; 7, TERRACE DEPOSITS.

blage are creatures whose characters only remotely resemble those of animals living today. Such, for example, are the ubiquitous members of a tribe of herbivorous mammals called oreodons, often spoken of as ruminant hogs. Among all the animals uncovered in the John Day by either the professional collector or the layman, these are the most common. While oreodons occur in both the green- and buff-colored deposits, differences prevail between them, and the largest specimens are found in the upper strata. In size, in proportions of the body, and apparently also in some of their habits, the oreodons show resemblance to swine and peccaries, but they differ greatly from these animals in other respects. Their teeth, to cite merely one of their structural characteristics, are not at all like those found in pigs and peccaries but are very similar to the teeth possessed by the cud-chewers.

The oreodons were distinctively North American mammals, for they not only originated on this continent, but their subsequent history and ultimate extinction likewise occurred here. Presence of mammals having no intimate blood affiliation with creatures found fossil elsewhere in the world may imply an absence of land connections between North America and other continents, as in this instance during the time of accumulation of the John Day deposits. On the other hand, there may be other equally good reasons why these animals were restricted to North America. At any rate, the evidence stands in contrast to that obtained from a later formation in the John Day area, in which instance the relationships of certain fossil mam-



THE VALLEY OF THE JOHN DAY RIVER

LOOKING NORTH FROM PICTURE GORGE. BEYOND SHEEP MOUNTAIN A PORTION OF BUTLER BASIN IS SEEN. RED, GREEN, AND BUFF-COLORED JOHN DAY DEPOSITS ARE EXPOSED AS BADLAND SURFACES ON THE FLANKS OF SHEEP MOUNTAIN. THE REMAINS OF MAMMALIAN FOSSILS ARE FOUND IN THEM.

mals strongly suggest a continental connection at that time between North America and Asia and between North and South America.

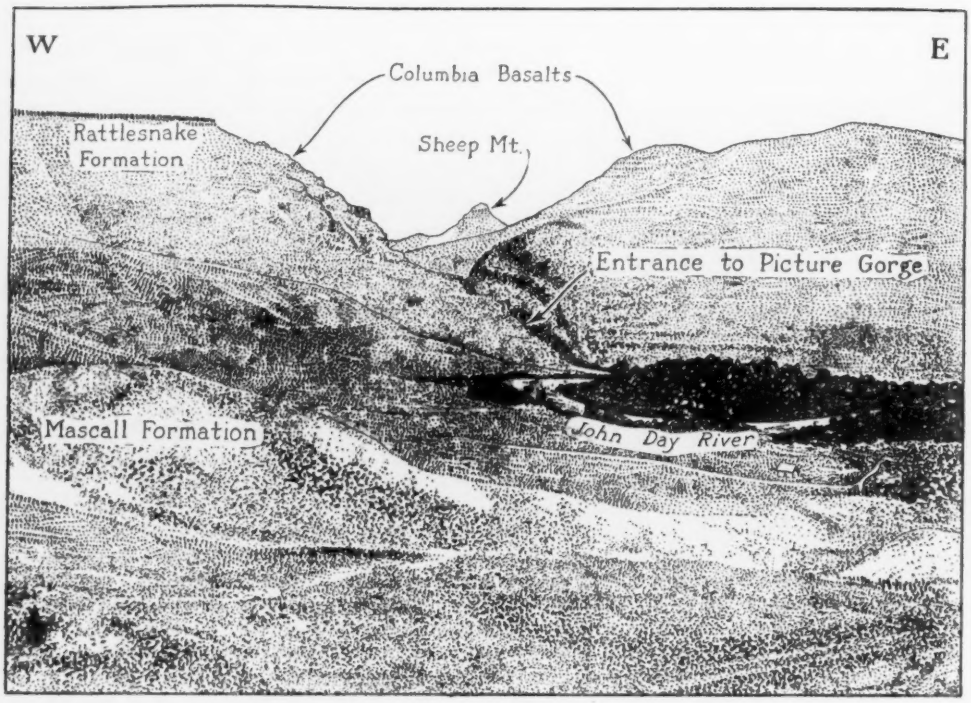
Other kinds of fossil mammals found in the John Day beds are rhinoceroses, tapirs, and camels. While these possess distinguishing characteristics of their own, they show a basic resemblance to their respective living representatives, which suggests a broad and more or less direct relationship with them. The presence of living rhinoceroses in Africa and Asia, of tapirs in Brazil and Malaya, of camels in Asia and Africa, and of llamas in South America serves to emphasize the strangeness and exotic character of the mammalian life of that ancient epoch in Oregon.

Lastly, an early member of the horse family from the John Day should receive specific mention because of its scientific and popular interest. Some especially fine specimens of Miohippus, as this primitive horse is called, have been found in the green-colored strata of the middle John Day. Our knowledge of this interesting creature is sufficiently complete to tell us that it stood about six hands at the withers, on both front and hind feet there were three well-developed toes, and its grinding teeth were short-crowned, as they are in a browsing mammal.

The lineage of the horse family, regarded by the student of evolution as an excellent example of that growth with change which organisms undergo as they evolve in geologic time, comes by this significance precisely for reasons so well demonstrated in the sequence of geologic formations of the John Day basin. For, while the oldest horse found in the John Day deposits is not the most ancient, it is a beginning member of an interesting series in which each type found in successively higher and superimposed fossiliferous formations is more advanced or more specialized than its antecedents. It is as though the horses kept pace with a changing earth, remaining not unchanged themselves, but showing in the several stages of their advance a trend to larger, more efficient types in their adjustments to earth movements, changing environments, and diminishing rainfall.

The John Day fossil assemblage could not have lived under semiarid climatic conditions like those which now exist in the area. The abundance and variety of the animal life furnish some of the evidence in support of this view. Presence of individual kinds of mammals, like the tapir, rhinoceroses, giant pigs, peccaries, opossum, certain of the rodents, browsing horses, and possibly the oreodons, may be taken to indicate the existence of considerably more verdure and thus decidedly more moisture than occur there at the present time. As a matter of fact, an abundant and beautifully preserved flora found in the lower John Day beds clearly indicates that the climatic conditions were temperate and wet.

After the entombment of this diversified life in the John Day deposits, this formation was folded and eroded. Subsequent to these events came the great episode of upwelling of basic lavas. The molten rock issued from fissures developed in the surface formations of the region and engulfed not only the John Day country but a vast contiguous area as well. The Columbia basalts lay like a pall over the buried relics of the past, and for a moment, geologically speaking, all living things were driven from the region or were destroyed. How different must have been the landscape when the existing topographic relief was shrouded by successive layers of a basaltic mantle! When, however, at the close of this important history, the outflows of lava gave way to explosive activity and ash showers, a new cycle of sedimentation was initiated, and accumulation of fos-



THE JOHN DAY RIVER AT PICTURE GORGE

ON THE LEFT CAN BE SEEN THE WHITE ASH OF THE MASCALL FORMATION RESTING ON COLUMBIA BASALT. OVERLYING THE MASCALL IS THE RATTLESNAKE FORMATION, CAPPED BY A RHYOLITE FLOW.

sil material again became possible. The Mascall formation of volcanic ash, silts, and reworked ash lies on top of the Columbia basalts, the lower strata of ash being interbedded with the upper lavas of the basalt series.

In successive horizons of the Mascall are evidences that the strata were laid down in lake basins, along the borders of fresh-water bodies, and on the land. Life again tenanted the region. Plants established themselves on the landscape, as shown by a multiplicity of leaf fossils found in particular horizons. At a certain level an earthy ash contains the principal representation of fossil mammals found in the Mascall. The known animal assemblage is not so large nor so varied as that from the John Day beds.

Predators, hoofed mammals, and smaller forms like rodents are known by fossils found in the Mascall formation. Oreodons are present, and at least one of these is more advanced than those found in the John Day deposits. A peculiar member of the deer family (Dromomeryx), which possessed curved, clublike horns, is represented by one or two fairly good skulls and some skeletal material. Remains of camels and horses are also found. One of the horses, called Merychippus, resembled a pony in size. Its feet still had three toes, but the side toes on each foot were more reduced in size than in the earlier horses collected in the John Day formation. The permanent grinding teeth, in contrast to those of antecedent types, possessed greater efficiency for chewing gritty grasses, as shown by their longer crowns and by the more complicated enamel pattern of their wearing surfaces. Students of the horse group regard these characteristics as an indication of a

progressive development in the course of which grazing habits were acquired. Other kinds of fossil horses are likewise present, but these retain more primitive characters, although they are also in advance of the horses found fossil in the John Day deposits.

The flesh-eating mammals include a huge bearlike dog and another member of the canid family that serves well as an ancestor of the modern wolves. Still another carnivore of small size found here shows a curious resemblance to the mustelids and raccoons. The mammals found fossil in the Mascall formation apparently once had a wide dispersal in southern Oregon and adjacent regions, for essentially identical animals have been recovered from sediments of Mascall age at a number of widely scattered localities in this general area. The entire assemblage, like that from the John Day deposits, reflects the existence of a moister climate than prevails in the region today. This view receives added support if in the group are included the fossil mammals collected in deposits of equivalent age at localities adjacent to the John Day basin. The browsing horses, camels, deerlike antelopes, possibly Dromomeryx, as well as some of the squirrels and members of the mountain beaver group, may all have lived under climatic conditions which were not so wet as during John Day time nor so dry as during the epoch of deposition which followed.

Subsequent to the time of entombment of this assemblage of life, the Mascall formation and the several groups of strata which lie beneath it in the John Day basin were folded. The Mascall was eroded, and on its truncated edges were laid down, at a still later time, another series of deposits called the Rattlesnake formation. These comprise gravels, tuffs, and relatively thin outflows of acidic lavas (rhyolite). The

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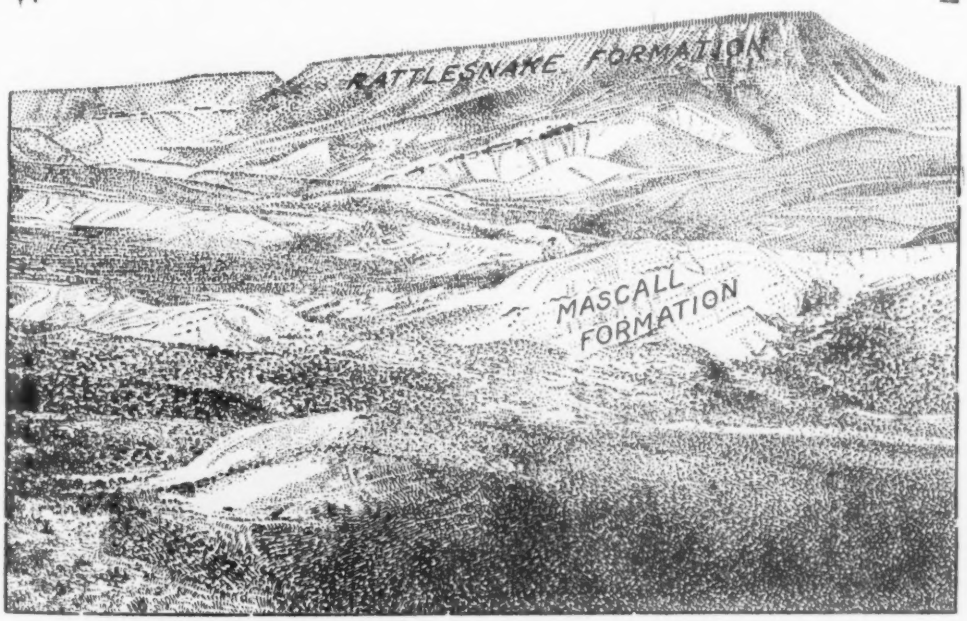

RHYOLITE-CAPPED BUTTES ALONG RATTLESNAKE CREEK

THIS REGION LIES IMMEDIATELY WEST OF THAT SHOWN OPPOSITE. THE FOSSIL-BEARING MASCALL MIOCENE IS OVERLAIN UNCONFORMABLY BY THE FOSSILIFEROUS RATTLESNAKE PLIOCENE FORMATION.

sedimentary deposits appear to be largely stream-laid. The interval which separates the Rattlesnake from the Mascall helps to demarcate sharply the two formations and the fossil assemblages which occur in them.

The fossil mammals collected in the Rattlesnake are not only entirely different from those known from the Mascall, but wherever related forms occur in both, the more advanced or progressive types are found in the upper or later formation. Within the horse group, for example, are two distinct kinds, one (Pliohippus) in the line of descent to the modern horse, the other (Neohipparion) representing a side branch destined to die out. Both, however, are definitely more advanced or specialized than the horses in the Mascall. In Pliohippus apparently the feet had reached a stage of specialization wherein only a single functional toe, the third, was present, and the side toes were so greatly reduced in size as to reach the point of complete disappearance.

Neohipparion, on the other hand, retained the side toes. As the animal stood on its median or third toe, the side toes were off the ground to at least a slightly greater extent than in the Mascall Merychippus. Then, too, both Pliohippus and Neohipparion were larger than the Mascall horses, and their grinding teeth were even better adjusted to grazing habits.

Rhinoceroses are known, and these were among the last of their kind found fossil in North America, for the group became extinct either during the time of accumulation of the Rattlesnake formation or shortly thereafter. Camels of very large size and peccaries were present, as also were relatives of the modern pronghorn antelope. Among the large and small forms can be listed mastodons, rabbits, and a squirrel. The predatory animals included cats, mustelids, an ancient coyote, bearlike dogs, and a bear. The bear is a particularly interesting creature because it closely resembles, or is identical with, a fossil bear described from northern India. This intimate relationship between two forms so widely separated geographically is some of the evidence regarded by students of American fossil mammals as implying that North America and Asia were joined by land at a time when these animals were in existence. A similar case is presented by the occurrence of remains of extinct ground sloths in the Rattlesnake deposits. In this instance, the appearance of creatures with South American affinities in the Rattlesnake and absence of comparable mammals of southern origin in earlier fossiliferous horizons furnish a clue to the time of establishment of migratory routes for land animals between the two continents.

The record of many grazing horses and an absence of browsing kinds in the Rattlesnake, as well as presence of grazing antelopes and large camels, suggest that the environmental conditions then were somewhat like those that exist today on the central high plains or on the high plateaus of the Far West. That the area was not all grassland and that wooded regions were also present is suggested by the occurrence of rhinoceroses, mastodons, and peccaries. But a survey of the entire fossil assemblage leaves the impression that the climatic conditions at the time of existence of these animals were considerably more arid than during the period of accumulation of the John Day sediments and also drier than during the time of the Mascall deposition.

In the vicinity of Picture Gorge, where it is seen to best advantage, the Rattlesnake formation shows definite signs of disturbance by earth movements. These, however, were not so severe as were those that folded the strata of the John Day basin at times prior to the deposition of the Rattlesnake.

The last stage in the history of life of the John Day area, before the coming of Recent time, is recorded in terrace deposits now exposed along the present stream courses. In comparison with the earlier fossil assemblages, this unfortunately is a meager one, for it comprises only extinct species of elephants and an equine essentially similar to the modern horse. In at least the latter instance fossil evidence indicates that the earlier mammals continued in their evolution to higher, more advanced, or more specialized kinds. This last member of the horse group is clearly separable from the fossil equines found in the Rattlesnake formation. In stature and apparently in those specializations of bodily construction to which attention has been directed before, it shows a definite step forward beyond its nearest relatives occurring in the Rattlesnake. In these characteristics it shares its exalted position with that tried and useful servant of man, who today gives patient service before hayrick and harrow in the valley of the John Day.

Reviewing these chapters in the geologic history of the John Day basin, the student of the earth sciences comes to appreciate the individuality of the several rock units exposed there, the relationships which exist between them, and the fossils which they contain. In determining the super-position and sequence of these strata, the geologist ultimately comes to integrate this local history with that written in other areas. He establishes a more or less standard scale whereby all geologic history is recorded with reference to the passage of time. In the present instance, the specific events fall into geologic epochs recognized under an accepted terminology of universal application. Thus the Clarno formation is assigned to the Eocene, the John Day formation and its fossils are referred to the Oligocene and Miocene, the Columbia lavas and the Mascall to the later Miocene, the Rattlesnake to the Pliocene, and the terrace deposits to the Pleistocene, or Ice Age.

But in the larger sense the geological story, here outlined for the John Day basin, demonstrates effectively the mutability of earth and of the living things upon it. In shifting scenes of the same region are glimpsed the changing surface features of the earth, various ways in which geologic formations are laid down, and alterations in climate during certain stages of the Age of Mammals, wherein the direction of change is from moist to drier conditions. In such unstable surroundings it is perhaps not surprising to find that life likewise becomes modified. With elapse of time not only do old forms disappear and new forms appear, but where particular lineages among mammals can be traced, there is definite evidence of evolution.

The movement of life upward through the ages seems to be accompanied by a change from the general to the particular, from the primitive to the more advanced, from a state of more or less efficiency or of specialization to one of greater efficiency or specialization. Not all lines of development among the fossil mammals carry on into the present (many become extinct along the way), but the life of today is unquestionably an outgrowth of that of the geologic past. While the story of this life possesses much of local interest, certain facts stand revealed which, when placed in proper relation to others, take on added significance in time and space. Like the missing piece in a mosaic that falls into position and illumines thereby the larger meaning of its own design, so also, when joined with others, does an isolated fact derived from the fossil record often make clear its wider import in history.

THE WESTERN MUSEUM SOCIETY OF CINCINNATI

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CINCINNATI was one of the earliest centers of scientific activity in the Middle West. There, as part of the growth of the city in the early nineteenth century, two pioneer natural history societies were founded, the Western Museum Society in 1818, and the Western Academy of Natural Sciences in 1835. In the establishment of these two institutions there was being repeated the experience and practice of the older cities of the United States. In Charleston, Philadelphia, New York, Boston, and other places natural history study groups had been organized during the eighteenth century, and collections of plants, rocks, minerals, fossils, and birds and animals had been made. These societies and museums had come into being as the cities began to emerge from the settlement period and as a few fortunate citizens began to prosper financially. With this surplus of wealth over the demands of mere livelihood, the "upper classes" provided themselves with more luxurious homes and beautified the grounds around them. Having taken care of themselves materially, men indulged in intellectual and cultural pursuits, and natural history was a favorite hobby of eighteenth century gentlemen. They also exhibited a social conscience and were the patrons and financial supporters of libraries and schools for the improvement of the masses.

Schools, libraries, dramatic and debating societies, literary circles, and natural history societies of the eighteenth and early nineteenth centuries were developed largely because of the need for self-improvement felt in a new country. With no one but themselves to depend on, men provided educational, scientific, and cultural advantages for their communities through mutual cooperation and voluntary association.

As Ralph S. Bates in his recent study *Scientific Societies in the United States* (New York, 1945), William M. Smallwood in *Natural History and the American Mind*, and Carl and Jessica Bridenbaugh in their detailed account of Philadelphia *Rebels and Gentlemen* (New York, 1942) have all demonstrated, the advanced study of natural history and of science in general has been carried on chiefly in cities, and the foundation of scientific societies is essentially a part of the process of urban growth. A chart in Dr. Bates' book shows that the establishment of local scientific societies followed the movement of population westward. As natural history societies and academies of science were founded in the eastern cities in the last decades of the eighteenth century and the first two or three decades of the nineteenth, so in the 1830's, 1840's, and 1850's they were founded in Cincinnati, Cleveland, St. Louis, Chicago, and other cities of the Middle West as they outgrew their pioneer crudities and strove for the habiliments of civilization.

It is my purpose to illustrate the foregoing ideas by a study of the Western Museum Society of Cincinnati. The Western Academy of Natural Sciences was the first academy of science in the Mississippi Valley, and it has an interesting history. But the Western Museum Society attempted to do more than simply maintain a museum, and its his-

tory sufficiently illustrates the principles here set forth, although it was two decades in advance of the general movement.

While it is generally true that scientific societies, academies of science, and natural history museums were a product of city growth, certain other conditions were necessary. Economic success and population increase but prepared the soil. Individuals with enthusiasm and financial resources were necessary for the planting of the seed and its propagation. Those who first became interested in natural science were the doctors and schoolteachers. These came together to exchange ideas and frequently brought within their circle businessmen who had established their financial security and engaged in natural history as an avocation. From among the latter the money for the support of scientific research was obtained. In Cincinnati the man who started the Western Museum Society of 1818 and the later Western Academy of Natural Sciences (1835) was Daniel Drake, physician, author, businessman, and scientist. He provided both the initial stimulus and a portion of the financial backing for the Western Museum Society and organized the Academy.

Daniel Drake was a product of the Kentucky-Ohio frontier. Born at Plainfield, N. J., October 20, 1785, he was taken by his family to Kentucky when he was three years old. Near Maysville, his father, who is said to have arrived in the community with only $1.00 in cash, took up a small farm. He prospered and in 1794 acquired two hundred acres of land, much of it virgin forest. Young Drake thus experienced pioneer life as a farm boy but with an unusual sensitiveness to his surroundings. His biographer says that Daniel "looked upon all the elements and incidents of his early life in the woods with the fancy of a painter and the emotions of a poet." (There is no modern biography of Drake, and all sketches of his life, including that in the *Dictionary of American Biography,* by Albert M. Matthews, are based on Mansfield's *Memoirs.*) Receiving the usual meager schooling of the early settler, Drake was eager to learn and devoured such reading material as he could lay hands on. A cousin, John Drake, was a doctor, and it was planned that Daniel should study medicine with him. But John Drake died, and, after a family consultation, Daniel was sent off to Cincinnati as an apprentice to William Goforth, a leading physician of that city. By the time Daniel was nineteen he had progressed so far that Dr. Goforth accepted him as a partner, and the young man actively visited patients and prescribed medicine for them. But Drake knew that if he were to reach the heights of his profession, he should have training in a recognized medical school. In 1805 he went to Philadelphia to the University of Pennsylvania where he was under the tutelage of Dr. Benjamin Rush and other leading physicians. After his stay there he practiced medicine for a short time at Mays Lick, Ky., and returned to Cincinnati on April 10, 1807.

The city in which Drake decided to make his permanent home was experiencing a business boom that came from the accelerating movement of settlers into the Ohio Valley. Drake, certain that Cincinnati had a great future, began to take an active part in community activities. He became a member of a debating society, took part in amateur theatricals and in other efforts toward self-improvement. He married Harriett Sisson, a niece of Colonel Jared Mansfield, in the autumn of 1807. Colonel Mansfield, a mathematician and scientist, was at this time Surveyor-General of the United States and directed the land surveys in the old Northwest. He later became professor of natural and

experimental philosophy at West Point. On his farm at Ludlow's Station, near Cincinnati, the young and progressive leaders of the community congregated for social intercourse. And at the farm and in the course of his daily calls on rural patients, Drake pursued an already awakened interest in natural sciences. He opened an Indian mound and described the pottery and human remains; he collected plants and prepared a catalogue of those useful in *materia medica;* and he kept meteorological readings.

The result of this scientific study was a pamphlet *Notices of Cincinnati, Its Topography, Climate, and Diseases,* written in 1810 and expanded in 1815 as a book *Picture of Cincinnati and the Miami Country.* This famous work had a large circulation in the United States and in Europe. It embraced a description of the geography, population, aboriginal anthropology, and natural history of the Ohio country, as well as the political and judicial organization of the city, county, and state, and a discussion of the diseases of the people of the West. It ended with an account of the great earthquake of 1811–12.

Meanwhile, Drake was taking advantage of the opportunities for making money in business. He opened a drugstore, later selling it and transferring his attention to a general store for the sale of groceries, dry goods, and hardware. He also became a stockholder in a textile factory, the Cincinnati Manufacturing Company. In the period of business optimism immediately following the close of the War of 1812, American merchants were enthusiastic about the profits to be made from the resale of the cheap British merchandise that was being dumped on the American market. Drake decided to purchase goods for his store in the nearest port, Philadelphia. But the doctor had other purposes in mind, also. He wanted to secure his M.D. degree, study medical schools, and investigate the cultural and scientific life of the city. In the few months he was in Philadelphia in 1815 he visited museums, attended medical lectures, and met the scientific and literary leaders at meetings of the American Philosophical Society and of the Academy of Natural Sciences, and in the homes of such men as Dr. Caspar Wistar, president of the American Philosophical Society.

One of Drake's consuming passions throughout his life was the teaching of medicine, and, after his visit to Philadelphia and another year in Cincinnati, he accepted an invitation to become a member of the first faculty of the Medical Department of Transylvania University. But Drake was not satisfied with Lexington as a place to live. As Mansfield says, he aspired to be an eminent citizen as well as an eminent physician and scientist, and Cincinnati was rapidly becoming the Queen City of the West. Drake therefore returned in 1816. Writing at that time, he expressed his enthusiasm for the budding metropolis:

> Cincinnati continues to advance. This is so strikingly the case, that if you were here, you would perceive in its present aspect, a great contrast with what it had exhibited six years ago. Two steamboats have been completed at this place within the last eight months, and seven more are now on the stocks. The engines for them and all the iron machinery are made at an extensive iron foundry between our old house and the river. The town generally has undergone great alterations. All the principal streets will in a short time be paved. A horse ferry-boat had been built, and greatly facilitates our intercourse with Newport and Covington. Our two old newspapers have been enlarged to imperial size, and a third will be commenced on Tuesday next.

Again he wrote:

> There are also at this moment, arrangements making in Cincinnati that will render its institutions, at no distant period, as superior to those of any other town in the West, as its population and trade are pre-eminent. During the last week $29,000 were subscribed by seven gentlemen [Drake was one of them] as a permanent fund for the Lancaster Seminary.

> Within the same week a site for a poor house has been purchased, in a suitable situation, and the establishment has been planned in a manner that will make it a hospital, the only desideratum to the formation of a medical college in this place.

The Lancaster Seminary was the forerunner of Cincinnati College, now Cincinnati University. It had been founded in 1815 by Dr. Joshua L. Wilson, pastor of the First Presbyterian Church, with Drake as an enthusiastic backer. Drake was also working toward the establishment of the Medical College of Ohio, which opened its doors to students in 1821 and he was one of the founders of the Library Society in 1813.

Library, medical school, hospital, college—Philadelphia had all these, plus museums and scientific societies. Cincinnati must have them, too, and Drake called a public meeting to promote the establishment of a museum. He wrote:

> A Society has been formed, and I confidently expect to see from $5,000 to $6,000 contributed to that object next week. I have drawn up the constitution in such a manner as to make the institution a complete school for natural history, and I hope to see concentrated, in this place, the choicest natural and artificial curiosities in the Western country.

Thus, as a part of the cultural requirements of a great city was inaugurated the first organized effort to promote the study of natural science in the Middle West.

The constitution prepared by Drake provided that memberships should be sold for $50 and that the subscriber and his family should have free admission to the museum at all times. Five "managers" were named to secure contributions and to take care of the collections as they accumulated. The first managers were Elijah Slack, President of Cincinnati College, James Findlay, lawyer and editor of the newspaper *Liberty Hall and Cincinnati Gazette*, Jesse Embree, William Steele, and Drake. They published in 1818 "An Address to the People of the Western Country" in which they said that their first efforts would be directed "to the establishment of a permanent museum, on a scale so comprehensive as to receive specimens of every curious thing which they may be able to procure." It was their intention to accumulate four classes of objects:

1. Metals and minerals generally, including petrifactions.
2. Indigenous animals, embracing the remains of those which are now extinct.
3. The relics of the unknown people who constructed the ancient works of the western country.
4. The various articles manufactured for use by the present savage tribes.

Later the "promotion of the useful and ornamental arts" was made one of the society's objectives.

In July 1819, the Museum Society apparently had sufficient exhibits to begin regular meetings, but the museum was not formally opened until 1820 when its collections occupied rooms in the Cincinnati College building. At that time its exhibits and "philosophical apparatus" were valued at $4,000. The acquisition and preparation of specimens was in the hands of the managers and appointed curators. There were at least three of the latter. One was Joseph Dorfeuille, a wandering French naturalist and showman of uncertain antecedents. His special scientific interest was the natural history of insects, and as a result of collecting activities along the lower Mississippi he published two papers on entomology in the *Western Quarterly Reporter of Medical, Surgical, and Natural Science*. After the temporary closing of Cincinnati College in 1825 the collections of the Museum were placed in his care, and he displayed them along with his popular exhibits of antiquities, curiosities, and wax figures. Dorfeuille's museum was long a favorite place for entertainment in Cincinnati. He later went to New York where he maintained a show of wax figures while preparing a

work on "Antiquities of America." The manuscript remained unpublished when he died in 1840.

Robert Best, a young chemist and physicist who was Slack's assistant at Cincinnati College, was also a curator. His particular task was to make "philosophical apparatus" to "illustrate the principles of magnetism, electricity, galvanism, mechanics, hydrostatics, and the mechanism of the solar system." John James Audubon was associated with the museum as taxidermist for a few months in 1819–20 because of his skill in "stuffing fishes." Drake recognized Audubon's talent as a portrayer of birds but praised Alexander Wilson as the foremost American ornithologist.

Daniel Drake, however, was the guiding genius of the Western Museum Society. In 1819 and 1820 at the annual meetings of the members he delivered "anniversary discourses." In spite of the many self-improvement enterprises in which the people of Cincinnati were engaged, their first concern was the business of getting ahead in the world. They recognized in principle the desirability of developing the cultural life of their city but they frequently lost their initial ardor after the first burst of enthusiasm. Drake recognized that there was a tendency to backslide, and in his discourse of 1820 he said that there were two imperative reasons for commemorating the establishment of the Western Museum Society.

> First: At the expiration of the two years which have been spent in the collection and arrangement of curiosities, when they are prepared for public inspection, and the doors of the Museum are about to be opened, it is important that we should review the design and labors of the Society, and inquire what benefits they are liable to produce. Secondly: as the arts and sciences have not hitherto been cultivated among us to any great extent, the influence which they are capable of exerting on our happiness and dignity is not generally perceived, and they have consequently but few friends and admirers. It is therefore proper, that we should institute and continue to observe an annual festival in celebration of a Society established expressly for their promotion; that we may elevate their character with the mass of our people, and multiply the number of their devotees and patrons by the infallible method of augmenting their consequence.

Drake saw the Western Museum Society as an important and indispensable means of understanding and developing the natural resources of the Middle West:

> The plan of our establishment embraces nearly the whole of those parts of the great circle of knowledge which requires material objects, for their illustration. . . . Already, indeed, in the possession of many specimens in Zoology, Mineralogy, Antiquities, and the Fine and Useful Arts, we venture to indulge the hope, that even at this time, we can offer *something* to interest the naturalist, the antiquary and the mechanician.

But, said Drake, unless the collections were arranged in order according to the "most improved systems," such a body of substances as had been gathered would "neither gratify the curiosity, nor inform the understanding." This, however, was an objection "rather specious than solid," because it is in a new country that such a "multifarious assemblage is most proper." Older communities could have specialized cabinets and museums, but "young societies" must have general collections because everything is new and unsorted and unclassified. "Let no one, then, charge our Society with temerity for aiming at a general collection; nor regard as an evidence of vainglory and undisciplined ambition, what in reality, is both the effect, and indication, of our recent settlement in a new region."

In 1820 the Museum's holdings were little more than a cabinet of mineralogical and lithological specimens, examples of Indian handicraft, and relics from Indian mounds, but by 1823 the Museum had

> 100 mammoth and Arctic elephant bones, 50 Megalonyx bones, 33 quadrupeds, 500 birds, 200 fishes, 5000 invertebrates, 1000 fossils, 3500 minerals, 325 botanical specimens, 3125 medals,

coins and tokens, 150 Egyptian and 215 American antiquities, 112 microscopical designs, views of American scenery and buildings, tattooed head of a New Zealand chief and about 500 miscellaneous specimens of the fine arts and an "elegant organ." Drake painted a bright future for the Museum.

He saw it as a place for research into the habits and classification of the birds and animals of the Middle West. It was to be an institution for the study of anthropology and a laboratory in which experiments in natural philosophy might be conducted. He said it would be a means of education for the mass of the people, and declared that, as a new nation based upon the principles of freedom and democracy, our future would be determined by the way literature and science were studied, for it was from these that we would acquire "refinement and elegance" and "progress in the mechanical and chemical arts."

Finally, he urged his fellow-citizens to support the Museum Society and aid it in attaining its objectives. In peroration he said:

> If we perceive, then, in the increase of useful knowledge the true secret of our permanent happiness; if literature can supply the talismanic agent of our prosperity, like a "pillar of fire by night," direct our wandering footsteps to the temple of glory, let us not ignobly stay our hands from the labors by which, only, philosophy and letters can be made to flourish. Let the architects of our national greatness conform to the dictates of science; and the monuments they construct will arise beautiful as our hills, imperishable as our mountains, which tower sublimely above the clouds.

Daniel Drake expected too much of the Western Museum Society as a promoter of scientific knowledge. Although Cincinnati was the leading center of cultures west of the Alleghenies in 1818, nevertheless the level of scientific knowledge there was not equal to that of the eastern centers at the same time. It was above that of other Middle Western centers, but, like them, its primary concern was the winning of economic security for its citizens. Drake and a few others were familiar with the general story of natural science. The work of Cuvier, Thomas Say, Alexander Wilson, and others was recognized. Drake was a corresponding member of the American Philosophical Society and the Academy of Natural Sciences of Philadelphia, the two most important disseminators of scientific information. The new *American Journal of Science and Arts* also had its readers in Cincinnati. The first strictly scientific publication in the Middle West was the *Western Quarterly Reporter of Medical, Surgical and Natural Science,* published in Cincinnati. The two volumes that appeared had articles by Cincinnatians J. P. Foote, James Flint, and Joseph Dorfeuille. Whether the Western Museum Society inspired these writers or whether their interests was a factor in the foundation of the Society cannot be determined. It is significant, though, that individuals were thinking about natural science, and that they joined together to stimulate general enthusiasm for natural history study.

The Western Museum Society flourished but a few years and never reached the goals set for it by Drake in 1820. Drake's personal interest flagged when he became involved with the organization and promotion of the Medical College of Ohio, fought a losing battle with his fellows on the faculty for control, and left Cincinnati for a place in the Medical Department of Transylvania University. He did not return to Cincinnati until 1827. The business decline that began in the East in 1819 hit Cincinnati about 1821, and Drake and others suffered financial reverses. Cincinnati College, too, was affected and had to close its doors in 1825. All these things together cut short a most promising, if overly ambitious, endeavor to promote the study of natural science in the Middle West.

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SCIENCE ON THE MARCH

VICTORY ON THE POTATO FRONT

POTATOES are weapons of war. This is the story of how a lowly but dangerous fungus helped to defeat Germany in two wars, how it backfired, threatening American food production, and how modern science has brought new discoveries to bear on the century-old problem of controlling the potato blight fungus, cause of famine and migration.

Just a hundred years ago, with the fury of an atomic explosion, the murrain, or blight, first swept across a million acres in England and Ireland, leaving a devastation of foul, rotted potatoes, bringing death from starvation and disease to a quarter-million Irish farm folk or driving them to migrate away from the blight-cursed potato fields—to America.

Most people believed that the blight was a mysterious Visitation of God, something beyond the grasp of mortal minds, but the scientists of those days thought differently, and soon the brilliant young German botanist Anton DeBary proved that the blight is the work of a microscopic mold fungus, a living parasite of the potato plant.

Too late to save the victims of the potato disease epidemic, a temporary remedy was found—Bordeaux mixture spray—and until recently this has been the potato grower's only defense against the ever-present danger of ruin from blight. Shortage of labor and spray chemicals let down the bars against the blight fungus in both world wars. In wartime potatoes are essential both for food and industrial alcohol. Their production is sorely handicapped by wartime lack of fertilizers, of farm manpower and machinery, and even lack of land that must be devoted to other purposes. When to these handicaps is added that of desolating plant disease, the resultant crop shortage becomes a major factor in turning the tide of battle.

Germany lost the first World War chiefly because of her food shortage. There the potato is the chief source of carbohydrate, and many Germans remember the terrible "turnip winter" of 1917–18 after blight had destroyed the potato crop and the war had to be waged on a diet of turnip soup, baked turnip, turnip pie, and grass-root "coffee." Again in World War II there was a potato famine in Europe, and although we do not yet know all the circumstances leading to the potato shortage, there are indications that blight was again on the rampage, sabotaging the Axis' crops.

But the potato blight fungus is no partisan. The potato fields of the Allied nations also bowed under the vicious attacks of the dreaded disease in both wars. The 1916 potato crop in the United Kingdom was one of the poorest on record, but a well-organized spraying campaign in Ireland throughout the war salvaged a million tons that would otherwise have been sacrificed to blight. The lesson had been learned, and when in 1943 England was again visited by "one of the worst blight years in living memory" spraying increased yields by 25 percent.

Nor did America escape. The mildness of blight attacks in 1940 and 1941 lulled growers into a false feeling of security, and they were not prepared for the unparalleled blight blitz of 1942 that destroyed 25,000,000 bushels of the crop and extended far to the West and South, in areas where it had never before caused damage.

Here was a challenge to our agricultural scientists, and, undismayed by the

fact that no great progress had been made against the fungus in many decades, they took up that challenge with the same will as their brother scientists working on war chemistry, aircraft design, and munitions development. And it was well they did, for 1943 again brought a severe general blight epidemic; in 1944 there was some relief in the North, but the disease was the worst ever in parts of the South; and the crop of 1945 was exposed to another lashing outburst even in the Great Plains where blight had never before been injurious. But thanks to research, scientists and growers were ready for these outbreaks. Threatened disaster was averted, and discoveries were made that promise complete control of the blight fungus for the future. Here are some of the points of attack on the problem.

Blight is erratic in appearance. There may be several years in which the disease fails to appear. During those years it is wasteful to spray the crop. Danger seems far away until growers are stirred to action by the sudden reappearance of blight in all its destructiveness—too late to save the crop. If there were only some way to know in advance that an epidemic is imminent! That was the point of attack used by Dr. I. E. Melhus, of the Iowa Agricultural Experiment Station.

The blight fungus is always around, waiting for a chance to start operations in a big way. Dr. Melhus' careful study of the relationship between temperature, rainfall, and blight during many years past showed that following certain weather conditions blight inevitably breaks out. These conditions include subnormal temperatures and excessive rainfall early in the life of the potato plant, weeks before the disease becomes apparent.

In 1942 Dr. Melhus organized a "Forecasting Service" which included many observers dotted about the main potato states, widely scattered test plots planted with infected potatoes which would react sensitively to "blight weather," and a clearinghouse of weather and blight reports, where the approach of an epidemic could be charted from day to day, much like the British aircraft warning service.

In 1943 evidence was obtained well in advance that blight was active. Weekly blight forecasts and spray warnings were issued by radio, press, and mail. In some areas the epidemic developed into one of the worst in 25 years, but growers were ready for it and hurried to the fields to put on the lifesaving coating of spray before the damage was done. Spray machines and supplies were rushed to the threatened areas, and many millions of bushels of potatoes were saved from certain destruction.

Bordeaux mixture spray takes copper, a war-vital material. The supply available to farmers became scarce. What good was a spray warning if spray material was not available? Again scientific know-how came to the rescue. Drawing on their backlog of accomplished experiments and conducting new ones, plant pathologists disclosed a number of new, potent fungicides that contain no war-scarce metals.

One of these, known to chemists as sodium ethylene bisdithiocarbamate but which farmers prefer to call "Dithane," proved to be an excellent potato fungicide in such widely separated states as Maine, Colorado, New Jersey, and Wisconsin. In Texas it increased potato yields from 80 to 242 bushels per acre and in Florida it completely outclassed Bordeaux mixture, giving yields 60 to 100 bushels per acre higher than those from Bordeaux-sprayed fields, bringing in $1,500,000 of extra cash to south Florida growers.

Along with the problem of spray materials there was a critical shortage of spray machinery, and the solution of that problem is a testimonial to the ingenuity of county agents and other agri-

cultural advisers in getting the greatest possible use out of existing equipment. One of the most successful methods of stretching spray equipment was the organization of "spray rings."

In the work of the spray rings, large sprayers operate on a cooperative or contractual basis to get the greatest sprayed acreage out of each spray rig. Each farmer of the ring contracts for the spraying of a given number of acres for 3 years, and at the proper times, indicated by spray warnings and following the recommendations of the agricultural experiment stations, a skilled operator puts on the needed applications. Besides conserving equipment, growers have learned of many additional advantages in this method of handling the spray problem. It is often cheaper than for each farmer to do his own spraying, the large sprayers are more efficient than small ones, there is no interruption of the farmer's other work, and maximum protection of the crop results from having the job well done at the right time.

In Pennsylvania 100 spray rings, spraying 16,000 acres on 2,300 farms, sprayed more than one-tenth of the state's potato acreage. Had there been a sprayer on each farm instead of the 100, it would have required 2,224 more tons of steel, the same number of pairs of tires, and over half a million more man-hours of labor to do the work. New York soon followed Pennsylvania's example, and in 1944 the number of spray rings doubled that in 1943. The idea is rapidly spreading in other states, and the scope of the work is being extended to include custom potato digging. Spray rings, saving the small grower the cost of idle equipment, are here to stay.

One of the most damaging aspects of blight is the storage rot that develops in apparently sound potatoes from blight fields. In the winter of 1943–44 one-fourth of the Maine crop rotted in storage, chiefly because of blight, in the greatest crop shrinkage in memory, and potatoes that were shipped out in supposedly good condition arrived at their destinations showing much decay.

This storage rot is the work of the blight fungus, which is washed by rain water down the stalks of potato plants just before digging time, making itself a foxhole in the tubers, sometimes without any external signs of disease. The problem was to find some way of blocking that downward migration of the fungus from diseased leaves to still healthy tubers.

The blight fungus cannot survive on dead leaves. Why not kill those vines after their food-gathering work is done? The new weed-killing chemicals provided the answer, chemicals such as "Sinox" and "Dowspray 66." The vine-killers are living up to expectations. Tests in Maine, for example, showed that tuber rot was reduced from 40 or 50 percent to 3 percent by killing the vines with Sinox. Slightly infected seed tubers are a principal means by which the blight fungus survives from one crop to the next, and an important effect of vine-killing is to reduce the number of infected seed tubers which would endanger next year's planting. Other advantages are observed: the "artificial frost" produced by the vine-killers makes digging easier, permits earlier harvesting to obtain the advantage of high prices for new potatoes, and avoids the development of secondary, offtype, and oversized tubers.

But the blight fungus has still another way of getting through the winter. Scientists Reiner Bonde and E. S. Schultz in Maine discovered that the potato dump pile, where cull potatoes are thrown, is a reservoir of infection for the fields next spring. Many of these cull potatoes are infected with blight, and some of them survive the winter and sprout early in the spring, sending up young shoots that are heavily laden with the pale white spores of the fungus.

These will often be wind-borne to nearby potato fields and start the infections that soon sweep across whole communities. There were some 6,500 dangerous dump piles in Aroostook County alone, and the Maine growers took action. They got a law passed making it an offense to allow dump piles to threaten their crops. Posters advertised the danger; thousands of farmers signed pledges to do away with the dump piles by burning or burying them or feeding the potatoes to livestock. Here again the new weed-killers came into use: they can be used to keep down the sprouts even when the dump pile is not destroyed. The practice of destroying the dump piles soon spread to Wisconsin, Colorado, and many other states, and it was learned that this not only does away with a main source of blight, but also destroys other diseases and insects, including the potato bug, which breed in dump piles.

But perhaps the greatest accomplishment of the present and hope for the future lies in developing new types of potatoes that refuse to give in to blight and resist attacks by the fungus. Maine growers alone spend $1,000,000 a year for spraying. A blight-resistant potato variety would save money, labor, machinery, and spray chemicals in time of war scarcity and lighten the economic burden of the potato grower in peacetime.

For a number of years potato breeders had been pioneering along this line with outstanding results just in time for needed war-crop production. New blight-resistant potato varieties such as "Sebago" and "Sequoia" are meeting with widespread approval for their quality and productiveness as well as their disease resistance. These are not immune from blight but suffer much less than the other varieties and permit a greatly reduced spray schedule. "Sebago," which compares with "Green Mountain," is called the best late potato for Wisconsin and has performed well in Maine, New York, Florida, Michigan, Minnesota, and western Washington. Recently, however, "Sebago" has shown signs of losing its resistance to blight, and still more highly resistant or immune varieties are needed. Breeders have been aware of this, and New York bred varieties that are fully immune from blight, such as "Empire," "Placid," "Virgil," "Chenango," and "Ashworth," adapted to different regions, will be available in very limited quantities this fall.

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BOOK REVIEWS

MORE ABOUT CINCHONA

Cinchona in Java: The Story of Quinine. Norman Taylor. 87 + vi pp. Illus. $2.50. Greenberg, New York. 1945.

POPULAR interest in quinine has grown rapidly since the Japanese attacked the East Indies. Taylor's small book, addressed to the interested layman, attempts in seventy-nine pages of easy reading to give the nature of the "hidden scroll" of malaria: its cause, the discovery of quinine, British and Dutch attempts to establish a quinine industry in India and Java, respectively, and the history of final success in Java. This undocumented story (provided, however, with a selected bibliography) is hardly an improvement upon the several other brochures in this field. Too frequently Taylor circumnavigates the subject without attempting a beach-head. The distribution of cinchona in its native Andes is indicated only in a highly generalized map. Its ecology, even in Java, is vaguely treated. Some readers would like to know more of the circumstances surrounding Dr. Laveran's discovery of Plasmodium in 1800 at Constantine, Algeria. Occasional sentences contain a confused medley of ideas. Witness: "Man, the mosquito, and malaria are mere incidents in the life history of an organism that needs our blood for food, uses the stomach of a mosquito to complete its sex life, and in the process causes the most devastating disease known to science." When we remember that Plasmodium "is neither a fungus nor a bacterium" but "an unicellular organism not so distantly related to amoeba," it is engaging to read that the "gametocytes, in the stomach of a mosquito, complete the sexual act." With reference to Taylor's point about the misspelling of the generic name *Cinchona* by Linnaeus (instead of using the historically more accurate form *Chinchona*), it may be recalled that Linnaeus intentionally altered certain commemorative generic names—e.g., *Swertia, Boerhavia,* and *Valantia*—to render the personal names into more pleasing Latin. The best chapters, amounting to about one-third of the book, treat of the history of the introduction of cinchona into Java and its cultivation there. There is a very general account of Javanese agricultural practices by the agricultural chemist, Dr. Pieter Honig.

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MEDITATIONS ON MALARIA

A Malariologist in Many Lands. Marshall A. Barber. 158 pp. $2.50. University of Kansas Press. Lawrence. 1946.

MUCH has been written on the subject of malaria, but seldom in as entertaining a fashion as in *A Malariologist in Many Lands.* Dr. Barber's reminiscing leads the reader through several of the most malarious regions in the world, including Malaya, equatorial Africa, India, the Philippines, parts of southern Europe, Russia, and Central and South America. In each region he surveys the surrounding topography, highlights the significant features in the life histories of the more important mosquito vectors, and discusses the human factors affecting disease incidence and local control procedures. One theme predominates, and that is that people must have a clear understanding of the means of malaria infection if control is to be achieved.

My experience with many malaria-scourged peoples has persuaded me that if only one could convince people that mosquitoes carry malaria and teach them a few simple means of protection, a vast proportion of the disease would disappear almost overnight.

There are few enemies of health more dependent on human shortcomings than malaria. . . . (150).

Dr. Barber's experiences have led him to express himself on problems of wide public interest, For example, a question commonly raised during the war was whether the incidence of malaria in the United States would not increase following the return of thousands of parasitized soldiers from the South Pacific and other malarious areas. Evidence of general concern is not surprising when it is realized that over 90 percent of the initial combat troops landing in parts of the Solomon Islands contracted the disease and for the most part are still harboring parasites today. However, because of our improved medical treatment and increased knowledge of the disease and its prevention, Dr. Barber believes that there will be no outbreak of epidemic malaria in the United States as the result of World War II.

In a narrative of this sort one expects to be entertained by anecdotes, and the reader will not be disappointed in this respect. The solution to the mystery of the poisoned guests is but one example of the amusing recollections of a medical detective tracking down the sources of disease. In many instances Dr. Barber's assignments were in fields unrelated to malaria, but somehow mosquitoes and malarial parasites always commanded his first attention. The story of his travels and experiences is at once both informative and of general human interest and should prove attractive to laymen and experts alike.

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SCIENCE FOR THE LAYMAN

Atomic Energy in War and Peace. Gessner G. Hawley and Sigmund W. Leifson. 202 pp. $2.50. Reinhold Publishing Corp. New York. 1945.

THIS little volume can be recommended to those who wish to understand something of the background and principles of one of the foremost scientific achievements of history. This is true for those with technical training as well as for those with none. The former will find many of the early sections on the fundamental ideas of physics and chemistry, the source and forms of energy, and the how and why of explosions elementary, but they will look long before they find another nontechnical presentation as clear, readable, and concise as this one.

The first thirty sections (there are no chapters, although the authors' orderly arrangement would have permitted this more formal grouping) give us some recent and ancient historical background and the fundamentals mentioned above. The next twenty-odd introduce the nucleus, its particles and forces; radioactivity, natural and induced; the neutron; isotopes; the instruments of nuclear physics; and uranium, its isotopes and reactions with neutrons.

These are followed by a summary, useful in orienting the reader, and a statement, excellent though brief, of the staggering problem faced in translating the meager data and limited knowledge available in 1940 into a full-scale productive process.

The third portion is devoted to a lucid account of the facts, problems and solutions leading to the successful production of U–235, plutonium, and the atomic bomb. This follows Professor Smyth's report closely, omission and subordination of details having contributed materially to logical presentation and clarity with no sacrifice in accuracy.

The closing sections discuss briefly the

future military and peacetime possibilities of atomic energy and its social implications.

Atomic Energy in War and Peace may have been a "quickie" in preparation but will repay careful reading.

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Electrons in Action. James Stokley. 320 pp. Illus. $3.00. Whittlesey House. New York. 1946.

HERE is a nontechnical book on one of the more technical fields of physics, which turned out surprisingly well. With "electronic" becoming almost a catchword, this book is recommended for those who wish to learn something of the history, present status, and future possibilities of electronics.

Following a brief introductory chapter, three are used to introduce the electron, the vacuum tube, and the fundamental functions of these tubes in both their simplest forms and the more advanced forms, the Klystron and magnetron.

Subsequent chapters deal with the now commonplace radio and its more glamorous offspring, television (I found the historical material of particular interest); the electrons of the upper atmosphere and their part in radio transmission; fluorescent light; sound recording and reproduction.

Chapters ten and eleven should be of considerable interest to most readers since they present, in considerable detail, many interesting applications of electronics which, though important, have not received the public notice accorded to X-rays; the electron microscope; and medical applications such as induction heating and the measurement of body potentials, subjects discussed in the next chapters.

Next follows an excellent account of particles and their acceleration and use. The closing chapters deal with atomic energy, the author quoting freely from the Smyth report. An appendix presents the latest information available on radar and related ranging and navigation systems.

The book is well printed and contains fifty-four figures and thirty-two interesting plates.

MERRILL E. JEFFERSON
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You and the Universe. John J. O'Neill. 319 pp. $3.50. Ives Washburn, Inc. New York. 1946.

A CAPABLE journalist has undertaken in this volume to survey the advances of all fields of science from the Harvard Conference of Arts and Sciences in 1936 to the present and to interpret "the advanced erudition of the scientists in the terms of everyday speech"—a highly commendable end attained to an unusual degree in this collection of the author's science writings for the press.

The varied nature of the subject and its popular treatment make a detailed review impractical. Specialists in the several fields may question the selection of some of the featured stories as those of "timely interest and lasting value"—to quote the publisher—but the reader will enjoy an unusually high percentage of them and recognize many as news of the day, often wishing for the missing date line and illustrations. Book One: *Of Man* takes him from the gigantism of early humans and the possible implication of Milne's *tau* time (Anthropology), to Rhine's prerecognition and psychokinetics (Psychology) by way of Archaeology (item: poetry of the fourth millenium B.C.), Zoology (item: "living fossils"), Biology (item: environment vs. heredity), Physiology (item: light and health), and Medicine (item: curing with cold). Book Two: *Of the Universe* presents highlights from Climatology (item: how hurricanes are born), Mathematics (item: Einstein and space), Physics (item: atomic energy), Chemistry (item:

mineral wealth in the seas), and Astronomy (item: clouds in space).

O'Neill has an unusual facility in expressing technical subjects in a readable manner (the soporific character of statistics on population and longevity and the astronomical figures of nuclear and celestial problems is surprisingly suppressed), although at times the sustained daily-press pace is trying.

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TOM BARBOUR'S SHEARS

A Naturalist's Scrapbook. Thomas Barbour. 218 pp. Illus. $3.00. Harvard University Press. 1946.

AS NEARLY everyone knows, Dr. Thomas Barbour was the late Director of the Museum of Comparative Zoology at Harvard College, which was founded by Louis Agassiz. He died on January 8, 1946, in his sixty-second year. Judged by the gusto that exudes from his pages, Tom Barbour must have enjoyed very much indeed the popular writing that he engaged in during the last four or five years of his life. But actually he *was* a man of great gusto, and who would want an autobiographer to escape from himself? Whatever his writing lacks by way of polish and literary finesse it makes up for in the forthrightness and facile expression of a *bon vivant*. And then there was also in T. B. a goodly portion of the sublime ego, and this too was inescapable when he came to write and reminisce. But you would not expect a man who stood six feet five, mentally and physically, to shrink to a Lilliputian the moment he took pen in hand.

The present volume is just what its title indicates—a scrapbook. It is not a particularly important book when considered by itself, but it does fill a few gaps in T. B.'s recorded life and work and should be read along with his *Naturalist at Large, That Vanishing Eden,* and *Naturalist in Cuba.* For the most part it is concerned with matters of interest to other museum curators, anecdotes of museum life, some of the philosophy of Barbour's own museum administration and scientific work, and odds and ends of his thinking and writing. Included, too, are thumbnail portraits of some of his friends and associates at M. C. Z.—notably, Alexander Agassiz, Samuel Garman, Outram Bangs, and Walter Faxon. The "scrapbook" contains also considerable historical material relating to the Museum of Comparative Zoology, the Boston Society of Natural History, and the Peabody Museum in Salem, Mass. Finally come a reminiscent chapter called "The Spice Islands Forty Years Ago," describing the Barbours' trip to these islands about 1905; a similar travelogue on Bali and Lombok; and various and sundry paragraphs on the subject of zoogeography, on which Barbour was a recognized authority.

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COMMENTS AND CRITICISMS

Scientific Beachcombing

In the October 1945 SM, Mr. O. F. Evans gave his explanation of the formation of what have been termed "beach cusps." A close reading of this article leaves the student with the impression that the explanation is not complete and further that "beach grooves" are what are really made and the "cusps" are merely incidental small headland-like processes left after the grooves have been eroded.

In the December 1945 SM, Mr. Hiram W. Hixon says that Mr. Evans expresses his opinion, but does not give the cause of shore scalloping. Mr. Hixon then gives his theory, namely that water poured from a wide-mouthed graduate is drawn into reduced cross section by surface tension. He apparently overlooks the facts that increased speed due to gravity reduces the size of the stream, that a wave slides down a beach as wide as it dashed up, and that if his theory were correct, beach scalloping would be normal instead of a rather rare occurrence.

In the same issue Mr. Bassett Jones advances a theory that the size of the groove is dependent on the average size of the sand or gravel particles of the beach, the distance between mean high and mean low tides, and the average size of the breakers. His first and second points seem obscure, and it is a pity that he did not elaborate upon them.

Both of these contributors understood that the grooves are formed and that the cusps are incidental.

In the January 1946 SM, I advanced a purely speculative hypothesis which I termed probably "inadequate." This was to the effect that when two series of waves travel in oblique directions heavier nodes are formed where the crests cross one another. These nodes follow one another in straight columns, strike the beach at the same points repeatedly, and erode the grooves at those points.

In the March SM, Mr. Evans returns with a comment on my hypothesis. He cites an article by Mr. Branner thus: "A little over twenty-five years ago . . . in . . . 1900." He goes on to state that Mr. Branner "suggested the same hypothesis for the formation of beach cusps that Mr. Grant proposes."

I have studied Mr. Branner's hypothesis and find that it resembles mine only in that it makes use of wave series which cross one another. Mr. Branner deals with waves that approach the shore in concentric arcs, not in straight lines. He believes that a cusp is *built up at the point where the node strikes the beach.* My hypothesis is exactly the opposite; namely, that it is the node which erodes the groove. If Mr. Branner's theory were correct, beach cusps would appear as a series of mounds whereas in reality they remain as uneroded parts of the original beach level. Apparently Mr. Evans did not read either of the short articles by Mr. Branner or me carefully.—CHAPMAN GRANT.

Causation, Chance, Determinism, and Freedom in Nature

Dr. Paul Crissman states that the chance of drawing the perfect spade hand is the thirteenth power of one-fourth (December 1945 SM, p. 460). According to my calculations, the chance is equal to 52!/13!39!, which is less than one thousandth as great, according to my rough estimation.

In the next paragraph he states that, in tossing a penny, the number of heads may be expected to approach the value of one-half of the number of throws. This does not follow, since the penny is not symmetrical, and the divergence will be found to increase without limit. This can be easily seen by noting that heads exceed tails in each thousand throws. The discrepancy can be eliminated by counting heads for the first thousand throws, tails for the second, and so on alternately.—OWENS HAND BROWNE.

The Faith of Reverent Science

IN THE SCIENTIFIC MONTHLY of May 1934 you published an article "The Faith of Reverent Science" that impressed be greatly, stating so many things that I had thought out for myself. I think this deserves a wider reading. Would it not be possible to reprint it by itself or in a later issue of your periodical?—CARL P. NACHOD.

The above-mentioned address by the late William Morris Davis, of Harvard, was published on pages 395–421 of the May 1934 SM. It seems undesirable to reprint in the SM articles that have appeared in it. I am glad, however, to join Mr. Nachod in calling the attention of our more recent readers to this thoughtful essay. Only articles published elsewhere will be reprinted in the SM, and only a few will be so honored.—ED.

How Moses Crossed the Red Sea

The Biblical account of how Moses and his tribe got safely across the Red Sea, and how all their pursuing would-be captors were drowned in it, has been interpreted in different ways. Many believe it to be an account of things that miraculously did happen. With these one must either agree or disagree—there is no room for argument. Many others hold, on the contrary, that nothing of the sort described ever occurred—that the whole story is just a fancy garland for the head of a traditional hero or, perhaps, a clever bit of fiction on the part of an early ruler to awe his credulous people and thus obtain from them ready obedience to his edicts. With those who hold either of these beliefs, as with the fundamentalist, there is no room for discussion, except to inquire how this account, harmless brag or deliberate deceit, evolved first into folklore and then into an accepted belief so firmly fixed that none thought to doubt it.

Still others hold that Moses and his people actually did cross over safely and that their pursuers were drowned in the sea, but claim that everything came about as the result of natural causes. It has been surmised that a great north wind blew the water south from the upper end of the sea and that it was here and then that Moses crossed. But no one could march against a wind so strong as this would have to be, nor does the record mention a north wind, but one from the east. Besides no wind can blow both ways at once—to the right and to the left—in such manner as to clear out a broad passage, with water on either side, as described in Exodus.

Another surmise is that the water was pushed out of the upper end of the sea by a great increase there of the pressure of the air, and pulled back in time to catch the Egyptians by an equally great decrease of pressure. This looks, at first, to be a good guess, but it has a serious defect—no such changes of the pressure of the atmosphere as would be necessary to produce such effects as these are known ever to occur.

Still another suggestion is that the Egyptians were drowned by a tidal wave caused, presumably, by an earthquake. This might account for the disaster to the Egyptians but it would not make a way for the Israelites to cross over on dry land. Even the ebb that often precedes a tidal wave is of too short duration for the crossing of a multitde. Indeed all attempts to find an adequate physical cause for the alleged ebb and flow of the Red Sea appear to be hopelessly futile.

But there is another possible approach to this problem, one that accepts the honesty of the account and yet avoids appealing to the miraculous. This is, that Moses fled from Egypt by a route, perhaps little traveled, if at all, just beyond the northern end of the Red Sea, at a time when anyone who did not know definitely to the contrary would be sure that what he saw was, indeed, the Sea. However, on approaching it its waters would recede, and, on going considerably farther, part in the middle, with water to the right, water to the left, receding water in front and closing water behind, and dry sand underfoot though at the bottom of the sea only a few minutes before—a mirage all around. On getting across onto slightly higher land he could look back and see whatsoever might be pursuing him plunge into the sea he himself had just crossed and presently disappear beneath its surface—drowned, of course. Whereupon he would go on rejoicing.

Presumably, too, the Egyptians, being intent only on recapturing their slaves, gave over the pursuit as soon as, on nearing the mirage, they saw them (the Israelites) sink beneath the surface of the sea—hopelessly lost.

Just such a mirage, indeed, as that here supposed can even hide armies from each other, as one did during the battle of April 11, 1917, between the British and the Turks, in Mesopotamia. "The fighting had to be temporarily suspended," General Maud, the British Commander, reported, "owing to a mirage."

Anyhow, whether Moses did, or did not, go through a mirage, the account of his crossing the Red Sea is an excellent description of what he would have seen if he had done so.—W. J. HUMPHREYS.

Tax Capitalization

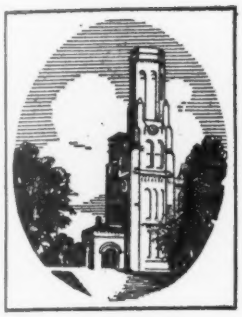
The empirical approach to economic theory, presented by Dr. Wehrwein, of the State Department, in his discussion of tax capitalization (May SM, pp. 447–449), is mischievously plausible as is all empirical argument in the social sciences.

In the hope of counteracting the mischief of his conclusion that "economic theory should not be made to be more logical or consistent than human beings or their economic activities themselves are," let us quote from a leader in economic theory, Prof. J. B. Clark, writing about "Capital and Its Earnings," over fifty years ago:

"Economic theory, whether recgonized or not, is a mainspring of political action, and a faulty theory, widely taught, is sure to bear fruit in bad action."

Must we forever remain as illogical and inconsistent as civilized society is today?—ALDEN A. POTTER.

THE BROWNSTONE TOWER



I have just returned to my desk from the top of Washington Monument where I gazed again on this beautiful city. How long will it remain a center of civilization? Will it grow to maturity or is it doomed shortly to become another Berlin or Warsaw? The release of atomic energy for destruction insistently raises these questions. The SM, "broadly interpreting to the thoughtful public the progress of science and its relation to the problems confronting civilization," would fail in its purpose if we should avoid this supreme problem. We do not intend to neglect it, yet we have hesitated to add to the flood of articles that have appeared on atomic energy and its control until we could present an outstanding essay worthy of our readers' attention. The leading article in this issue is the best that we have read since the fateful sixth of August, 1945.

Most intelligent, mature people have a long-established conviction that war can be prevented or suppressed only by world government. Many years ago H. G. Wells preached that doctrine and must have converted many of his readers. But the problem once nebulous has now become concrete owing to current events and to the efforts of scientists and students of government like Professor Schuman. His present essay dissects the problem with admirable clarity. Here is no wishful thinking but a lucid analysis of the present situation based realistically on what is politically possible. He urges continuous effort to promote concord among the Great Powers so that world control of atomic energy can be established within the UN. If that can be brought about as recommended in the Lilienthal-Acheson Report, the first and most important step toward a federated world government by law will have been accomplished. Perhaps the first small beginning was made when the Senate at last passed the McMahon Bill. If it becomes law, we shall then be in a position to negotiate for world control of the greatest menace to civilization that has ever arisen.

Professor Schuman, as a student of the history of government, is compelled to close his essay with a note of pessimism, which we think is fully justified by present events. When even those who are intellectually convinced of the necessity for a federal government of the world find it difficult to escape from habitual thinking in terms of nationalism and when the mass of people everywhere are not encouraged by their leaders to depart from traditional patriotism, there seems little hope that a change of heart will come in time to prevent the tragedy now in store for civilization. And yet everyone who understands the peril confronting the world must try to avert it by whatever means are open to him.

As Professor Keller says in his present essay on fear, "What men want is to eat, drink, and be merry. In dire peril, too imminent to be ignored, they have risen to the lift of a great Leader; but as soon as they cease to fear, they are ready to slump back into the comfort of 'normalcy' . . ." Our present danger is that we do not really fear the unseen atomic bomb. Like the people described by R.L.S., we are living on the slope of an active volcano. "There are serenades and suppers and much gallantry among the myrtles overhead; and meanwhile the foundation shudders underfoot, the bowels of the mountain growl, and at any moment living ruin may leap sky-high into the moonlight, and tumble man and his merry-making in the dust."

On this bright June day the Monument looks down upon the fairest works of man and nature. Will nature alone survive?

What a splendid world we could have if man would contend with nature only for his

own benefit! One of finest stories of man's fight against the malevolence of nature that we have ever published appears in this issue. Let us hope that men like Marston Bates can long continue their beneficent investigations.

The editor and his associates are always considering ways and means of improving the SM within the limits set by personnel and income. Those changes that seem desirable and feasible are made in the first issue of a new volume. Thus the present issue, beginning the sixty-third volume, is covered by coated paper on which the cover design has been somewhat modified. The primary purpose of this change is to improve the appearance of advertisements on the cover pages and to pave the way for the use of color on these pages. When and if Mr. Christensen contracts for a colored advertisement on the back cover, the black strip across the top and bottom of the front cover page will be changed to a suitable color, resulting, we hope, in a still more attractive appearance all around.

Color printing is so expensive that it is not a step to be taken lightly in the SM. We have been considering it for several years and are now authorized by the majority of our advisers to experiment with it in order to add to our experience and to find out whether our readers think it is worth while. Therefore we are beginning in a very modest way with the help of the Bausch and Lomb Optical Co. In their magazine called *The Educational Focus* (17(2): 11–18. 1946) the Company has published an article by J. V. Butterfield on "Color Photomicrography" illustrated by two pairs of colored photographs of certain crystals. The Company kindly lent us the plates of these colored illustrations and gave us information and advice about their use. They permitted us to reprint the article by Butterfield and gave us black-and-white prints of the crystals, which were not used in the original publication. Therefore we have published Butterfield's article in this issue with a colored insert so that the black-and-white photomicrographs can be compared with their colored counterparts. This was the least expensive way to make our first experiment in color, which would not have been undertaken without the generous support of Bausch and Lomb. Unless our readers disapprove, we will use color in principal articles from time to time when it adds scientific as well as esthetic value to illustrations and when color plates are provided or paid for by the contributor. It is our hope, of course, that we may be able someday to publish in the SM without cost to the contributor all suitable colored illustrations submitted with acceptable manuscripts.

Heretofore the items published under "Comments and Criticisms" have been given brief titles by the editor unless the writer provided a suitable title. The editor's titles sometimes reflected editorial reaction to the letters and sometimes were intended to be noncommittal. Titles of the latter character were often taken from some phrase in the letter to be titled. This practice led to an embarrassing incident for which the editor desires to make public apology. Comments on Major Chapman Grant's biological explanation of the origin of the Carolina "bays" (SM, December 1945) were entitled "On Grant's Fish Story," suggested by one of the letters. Major Grant was offended because it naturally seemed to him that the editor was indulging in ridicule. On the contrary, the editor feels that Major Grant's hypothesis is entitled to serious and respectful consideration, which it did not receive from those who commented on it. The same applies to his hypothesis on the formation of "beach cusps" (SM, January 1946), a comment on which was entitled "Armchair Geology." To prevent such misunderstandings in the future each letter commenting on a published article will bear the complete or partial title of the article eliciting the comment. This change in policy should help also to sooth one of our readers who feels that "Comments and Criticisms" is so lacking in dignity and scientific value that it should be eliminated from the SM.

F. L. CAMPBELL